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Status and Trends Monitoring for Watershed Health & Salmon Recovery: Field Data Collection Protocol

Wadeable Streams

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Status and Trends Monitoring for Watershed Health & Salmon Recovery: Field Data Collection Protocol

Wadeable Streams

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Introduction

Background

Purpose of this Document

This document serves as an instruction manual. It is intended for field crews that sample wadeable streams for the Washington State Status and Trends Program (S&T). The S&T is designed to assess streams and rivers on non-federal lands of the state over a 4-year period, with 2 Status and Trends Regions (STRs) sampled annually (Cusimano et al., 2006). Sampling is expected to begin in 2009 with the Puget and Coastal STRs.

History

In the last decade, there has been a growing interest in establishing statewide monitoring program for gathering consistent and integrated information on chemical, physical, and biological habitat. This is largely a result of federal mandates. For example, section 4(f)(1)(B) of the Endangered Species Act (ESA) indicates that de-listing requires an explicit analysis of the physical or biological conditions that affect the species' continued existence (NOAA 2007). The Clean Water Act (CWA, Section 101(a)) states: "The objective of this Act is to restore and maintain the chemical, physical, and biological integrity of the Nation's waters." The S&T is a response.

The 2001 Washington State Legislature passed Substitute Senate Bill 5637 requiring the development of a comprehensive strategy and action plan for measuring our success in recovering salmon and maintaining watershed health. This led to the development of *The Washington Comprehensive Monitoring Strategy for Watershed Health and Salmon Recovery* (MOC, 2002). This *Comprehensive Monitoring Strategy* calls for a statewide approach using several types of monitoring. Extensive (status and trends) monitoring is first on the list.

In 2005 the Salmon Recovery Funding Board (SRFB) provided support to the Department of Ecology (Ecology) the Department of Fish and Wildlife (WDFW) and the Conservation Commission (CC) for development of a sampling framework and Quality Assurance Monitoring Plan (QAMP; Cusimano et al., 2006). The framework and QAMP were developed through a series of public workshops (http://www.ecy.wa.gov/programs/eap/stsmf/).

In 2008, the Washington State Legislature provided start-up funding to the Puget Sound Partnership (PSP) to prepare for a 2009 field monitoring season in 2 of the 8 regions as proposed by the QAMP. Ecology was then tasked, through an Interagency Agreement with the PSP, to provide this manual and a database system, based on the QAMP.

Program Goal

The goal of S&T is to provide quantitative, statistically valid, and consistent estimates of the status and trends in physical, chemical, and biological conditions of Washington's rivers and streams. The data collected can be used to report on the health of salmonid habitat. Reports that can use this data include:

- State of the Salmon in Watersheds Reports (GSRO, 2009)
- Pacific Coastal Salmon Recovery Fund, Reports to Congress (NOAA, 2009a)
- CWA Integrated Assessment (EPA, 2006)

Monitoring Objectives

Monitoring objectives in the QAMP are supported by this protocol and include:

- Assess at multiple scales
- Assess with high statistical confidence
- Identify metrics and methods

Assess at multiple scales

This program was designed to be used for monitoring rivers and streams at multiple scales (e.g. statewide or regionally). The QAMP calls for the state to be fully assessed for status within a 4-year period, with 2 Status and Trends Regions (STRs) assessed within a year. Additional surveys at any scale can use this data to save monitoring costs, as long as these S&T protocols are used.

Assess with high statistical confidence

S&T is intended to report at a high level of statistical confidence (at least 80%). Precision is defined by the statistics of the EPA-designed framework, and the number of sites sampled. An excellent explanation on calculating the precision for the sample survey can be found at the EPA website (EPA 2009): http://www.epa.gov/nheerl/arm/surdesignfaqs.htm#manysamples.

Using consistent protocols among as many sites as possible, ensures precise status estimates.

Metrics and methods

Indicators

Indicators were chosen to include *Limiting Factors* of salmon production (GSRO 2008, NOAA 2009a) especially those statistically related to stream biotic community scores and those for which we have detected wide-spread low metric scores during the summer. The kinds of metrics that can describe these Limiting Factors are described in the QAMP (Cusimano 2006; see Figure 3 page 14).

Field Methods

Methods were chosen so that a small crew could access and sample each stream site within one reasonable working day. The intent is not to thoroughly characterize individual streams, but to describe the population of streams throughout the monitored region.

There are often better methods than those described here for characterizing individual sites, but many of these are impractical for status and trends monitoring. We have opted for fast, inexpensive, easily-trained methods that are repeatable.

For physical habitat measurements we have decided to heavily rely on Integrated Status and Effectiveness Monitoring Program (ISEMP) methods that have been in development since 2004 (Hillman 2004, NOAA 2009b). The ISEMP methods are useful because they:

- Integrate methods from multiple established federal programs (e.g., Hillman, T. W. and A. E. Giorgi. 2002, and Overton et al 1997, Peck et al 2006)
- Incorporated lessons learned from comparison studies (e.g., Roper et al 2008, PNAMP 2007).
- Fit a flexible database structure which we could adapt (Rentmeester 2008).
- Have been demonstrated as logistically feasible.
- Provide field data that can be calculated using published instructions (Kaufmann et al 1999).

Pre-season Site Selection

Overview

Before the season, each of the 387,237 points on the Washington Master Sample shapefile (WA_master_strah_112408) will be evaluated to generate a list of candidate sampling sites. Master sample sites were statistically chosen from the lines on a 1:24,000-scale hydrography frame (*WDNR watercourses, February 2005).*

Site evaluations determine the suitability of each site for monitoring at the level of a Status and Trends Region (STR). There are selection criteria for each site's statistical *target* status and for *accessibility* status . Each Master Sample site is evaluated in sequence from lowest to highest SITE_ID on the list. Evaluation for some sites on the list will not be complete until a crew can make on-site observations during the July-October index period.

These are the statistical **target criteria**:

1. Located in the Status and Trends Region (STR) of interest.
2. Not on federal land.
3. Member of a size class needing representation.
4. The stream on the sample frame is also in the National Hydrography Dataset (NHD).

5. Flow is lotic, perennial, continuous, and in a natural channel.
6. Freshwater.

These are the **access criteria**:

1. It is safe to access.
2. It is physically accessible
3. Permission has not been denied.

Target Status

Region

The STRs are based on Salmon Recovery Regions (SRRs) that were described by the Governor's Salmon Recovery Office (http://www.governor.wa.gov/gsro). The goal is to identify 50 sites and alternates in each STR (Table 1) that meet target criteria. These site lists will then be provided to field crews so that they can determine whether the streams can be safely accessed and sampled during the STR's designated field season. The procedure is to be started during months before the field season.

Table 1. Status & Trends Regions.

Status & Trends Region	**Salmon Recovery Regions included**
Puget STR	Puget Sound, & Hood Canal/Puget Sound SRRs
Coastal STR	Coastal SRR
Lower Columbia STR	Lower Columbia SRR
Mid Columbia STR	Mid Columbia SRR
Upper Columbia STR	Upper Columbia SRR
Snake STR	Snake SRR
Northeast Washington STR	Northeast Washington SRR
No Region STR	None

The "*salmon_rr*" attribute of the Master Sample shapefile represents the Salmon Recovery Regions

Non-federal

Exclude sites on federal lands using reconnaissance and parcel research. A first cut can be provided using attributes of the Master Sample file.

Size

Strahler order

The 50 sites in each STR will be allocated according to size class defined by Strahler (1952) stream order. This size designation is based on a hierarchy of tributaries. Headwaters are 1st order. Same-order streams converge into the next higher order. For our purposes, the Strahler order is based on attributes of a 1:100,000-scale hydrography dataset (Horizon-Systems, 2006). Since the sample frame is at 1:24,000-scale, some streams are too small to appear on the map that defines Strahler order. These are assigned 0-order.

We work down the Master Sample list in ascending order of SITE_ID until 10 sites and alternates are found for each Strahler stream order class below (and also satisfy the other selection criteria):

- 0-order
- 1st order
- 2nd order
- 3rd order
- 4th order or larger

Great Rivers

The main-stem Columbia River belongs to a group of water systems classified as "Great Rivers". This is a class that we are excluding from Washington's Status and Trends program, due to the necessary differences in sampling techniques. If a point represents a water course on the main-stem Columbia River, it is disqualified.

NHD

Target sites must be on streams that are represented by the National Hydrography Dataset (NHD) at 1:24,000-scale. These streams are identical in geometry to the watercourses that are now in use by the Department of Ecology.

Flow

Lotic

The stream or river must have lotic flow. Lotic means an aquatic system with flowing water such as a brook, stream, or river where the net flow of water is unidirectional (Armantrout, 1998). For this protocol, crews must also be able to see defined left and right banks to discern lotic from wetland systems. Lentic systems are discerned from lotic systems if they have a holding time of more than 15-days. If the point represents a watercourse that is actually a lentic system (lake, pond, reservoir, wetland), it is disqualified.

Continuous

If the point represents a water course that is interrupted (subsurface) for more that 50% of the site length, it is disqualified.

Perennial

If the point represents a water course that stops flowing on a seasonal basis, it is disqualified.

Natural Channel

A natural channel is one that was *not* constructed, although it might have been highly modified. Any constructed channel is non-target. This includes canals, ditches, or pipelines.

Freshwater

We want to exclude points that are associated with water that is not fresh. Freshwater means that the water is estimated to have more 95% of its water column with < 1 ppt salinity at any time during July-October. Multiple cues may be used to make this estimation (e.g. vegetation and proximity to a known estuary).

Access Status

Safety

Safety consideration can be estimated prior to the season, but it is ultimately the responsibility of individual crew members at the time of arrival to decide if the stream is safe to enter. Reasons for disqualifying a site from wading on a given date might include:

- Too swift
- Too deep
- Steep or unstable route of entry
- Hostile people or dogs
- Hornets (e.g. for allergic staff)

Physical barriers

A site can be disqualified from sampling if it would take more than a day to sample, including transit (camping is not supported by S&T). Barriers that would disqualify a site include things like extreme distances from parking.

Permission

Property owners will be contacted prior to sampling. This requires researching the parcel information in the preceding months. A site should be disqualified from sampling if permission has been denied by land-owners or resource managers.

Work Flow

Weekly

Schedule at least one whole day to sample each site. Depending upon travel distances, the work day might last longer than 8 hours. Plan weekly schedules accordingly. Also consider when the laboratory can receive samples for analysis. It generally works well to allocate more than a day each week for planning, cleaning, repair, and administrative duties.

Daily

The relative timing of daily monitoring activities is variable and should be performed considering efficiency of effort. It depends upon site-specific conditions. However, there are certain specific requirements in how the crew organizes its day. These are requirements:

1) Water should be sampled prior to in-stream activities upstream.
2) *In situ* measurements (the first of 2 sets) should be done at a similar time to water sampling.
3) Benthos and sediment should be sampled immediately after site layout.
4) *In situ* chemistry (time 2), is measured just prior to departure.

Table 2 provides an example of how a typical data collection event might be accomplished by a 4 person crew.

Table 2. Idealized daily work flow.

		Time Since Arrival On-site (Hrs)					
ACTIVITY	**PERSONS**	**1**	**2**	**3**	**4**	**5**	**6**
Verification& Layout	**AB**						
Water/In Situ	**CD**						
Benthos/Sediment	**AB**						
Habitat	**CD**						
Vertebrates	**AB+**						

Table 3 lists locations within the site where each of these activities is performed. Descriptions of these stations can be found in Appendix A.

Table 3. Activities by station within a site.

Major Transect	Minor Transect	Thalweg Transect	Near the Index station[f]
Slope & Bearing (10)[a]	Slope & Bearing (10)[a]	Slope/Bearing (0)[a]	Water samples
Wetted width	Wetted width	Thalweg Depth	In situ measures
Bankfull width	Bankfull width	Habitat Unit presence	Discharge
Bar width	Bar width	Side Channel presence	Sediment chemistry
Substrate sizes	Substrate sizes	Edge Pool presence	GPS[e] coordinates
Substrate depths		Bar presence	
Fish cover by class			
Shade			
Human Influence			
Riparian Vegetation			
Benthos[b]			
Vertebrate presence[c]			
Large Woody Debris [d]			
GPS[e] coordinates			

[a] Slope & Bearing: normally 1 measurement at each major transect and 1 at each minor transect. Supplemental measurements sometimes are needed from intermediate thalweg transects.
[b] The benthos sample is a composite from 8 randomly selected major transects.
[c] Vertebrates are sampled from the full length of the site, but records are updated at each new major transect.
[d] Large woody debris is tallied across the full length of the site, but records are kept for counts between major transects, on the *Thalweg Data Form*.
[e] GPS is required at site coordinates (index station) and at 2 major transects for wadeable streams (top and bottom of site).
[f] Except for GPS coordinates, these measurements can be done anywhere within the site, but near the index station is preferred.

Verification

Sampling crews will arrive at the candidate sample site, and verify that they are at the correct location (Appendix A), that the site meets target criteria, and that it is safe to enter. This protocol for sampling waded streams is restricted to sites that are less than 25 meters wide at the coordinates (sites less than 500 m long). Larger sites can be waded if shallow, but will be sampled using a different protocol (for raft-based work).

Water Sampling and *In Situ* Measurements

Water sampling and initial (time 1) *in situ* measurements should be performed prior to staff entering upstream. After verifying the site location, the crew can start by preparing the *in situ* instruments. The method for calibrations is in Appendix B. The method for *in situ* measurements is in Appendix C. Water sampling should be conducted according to the method described in

Appendix D. Final (time 2) in situ measurements are made, just prior to departure from the site. Discharge can be measured at a convenient time, according to Appendix E.

Benthos and Sediment

Depending upon the site-specific conditions, the same person might be assigned to sample benthos and sediment chemistry. Each sample should be collected prior to staff entering upstream from points of collection. Sediment is sampled according to Appendix F. The benthos sampling method is Appendix G.

Habitat

At any station within the site, persons measuring habitat should follow (in time) persons collecting water, sediment or benthos. The most efficient allocation and timing of staff to different tasks is dependent upon site-specific conditions. For example, sites with large quantities of large woody debris might best be measured by having one person dedicated to counting wood. Methods for measuring physical habitat are listed in Appendices H through S.

Sampling the Vertebrate Assemblage

Sample the vertebrate assemblage last (except final in situ measurements) by electrofishing all available habitats in the main channel from the bottom of the site to the top. Refer to Appendix T.

Data Form Review

Examples of the field data forms are found in Appendix U. Prior to leaving the site, these should be reviewed for completeness and accuracy. Crews will submit completed forms to Ecology at the end of the field season, prior to November 15. The forms will then be scanned for data and checked for errors before loading to the S&T database.

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Appendix A

Site Verification and Layout for Wadeable Streams

Purpose and Scope

This method explains how to verify (on-site) that a candidate wadeable sample site is suitable for sampling. It also describes how to establish the boundaries and stations within the site. Once a site is deemed suitable for sampling, a *Data Collection Event* (DCE) can be established to uniquely identify the sampling event.

Definitions

Definitions of acronyms and other terms are found in Table A-1.

Table A-1. Definitions.

Term or Accronym	**Definition**
alluvial reach	Where the form of the streambed is composed of appreciable quantities of sediments that are transported and deposited in concert with stream flow (Armantrout 1998). Most sites sampled for Status and Trends will fall into this category.
bedrock reach	Where the streambed **lacks fill material** except for temporary storage spots. Bedrock channels generally are **confined** by valley walls. (Montgomery and Buffington 1998)
braided reach	Braided reaches are characterized by **wide channels** containing **series of bars**. They have a **high supply of sediment**. They have **mobile bed** forms. They lack valley confinement and are characterized erodible banks. (Montgomery and Buffington 1993).
cascade reach	Cascade reaches occur on **steep slopes** where energy is high. They are characterized by disorganized **cobbles and boulders** and by **confined** valley walls. (Montgomery and Buffington 1998)
colluvial reach	Portion of the stream network that is **typically in headwaters** and typically consists of **intermittent or ephemeral flow**. In colluvial valleys, expect long-term **accumulation of sediment**, punctuated by periodic **catastrophic erosion**. (Montgomery and Buffington 1998). Colluvial

	material is of **mixed sizes**. It is recently eroded and transported locally through sheet flow such as avalanche or **landslide** (Armantrout 1998).
DCE	Data Collection Event. Data are indexed using this code which includes the SITE_ID, the date, and the time that the event began. It uses this format: **WAM06600-NNNNNN-dce-20YY-MMDD-HHMM** **NNNNNN** = the number portion of the SITE_ID. **YY** = the last two numeric digits of the year that the event occurred. **MM** = the two numeric digits for the month that the event occurred. **DD** = the two numeric digits for the day within the month that the event occurred. **HHMM** = the military time when the event began.
GPS	Global Positioning System.
Index Station	This is sometimes called “X”. It is the location of the coordinates that represent the site. Normally “X” is located in the middle of the site length (i.e. at major transect F), but sometimes the site position can be adjusted to avoid changes in Strahler stream order or to avoid property where access has been denied.
major transect	One of 11 equidistant transects across the length of a site. These are labeled as follows: A (lowest), B,C,….K (highest)
plane-bed reach	Plane-bed reaches are characterized by a relatively **featureless gravel/cobble bed**. There is an **absence of tumbling flow**, but may include glides, riffles or rapids. They **lack lateral flow**. Bed surfaces are often armored.
pool-riffle reach	Pool riffle reaches are typically **unconfined**, with a **laterally oscillating sequence of bars, pools, and riffles**. There is local sediment accumulation in discrete bars. (Montgomery and Buffington 1998)
regime reach	Mobile bed forms provide the primary flow resistance. Regime channels are typically **low-gradient sand bedded channels**. Low slope, frequency and presence of ripples or dunes throughout the channel bed distinguish regime channels from pool-riffle channels (Montgomery and Buffington 1993).
Site	A site is defined by the coordinates provided to a sampling crew and the boundaries established by the site layout method. Typically, the site extends 10 bankfull widths downstream from the coordinates and 10 bankfull widths upstream. The site also includes all riparian plots examined during the *Data Collection Event*. The site consists of many stations at which measurements or samples are collected.

Station	Any location within the site where an observation is made or part of a sample is collected.
step-pool reach	Step-pool reaches consist of **coarse materials** that are **organized into discrete series of steps** separating pools containing finer materials. They consist of alternating turbulent flow over steps and tranquil flow in pools. (Montgomery and Buffington 1998)
Thalweg	Path of a stream that follows the deepest part of the channel (Armantrout, 1998).
thalweg transect	One of 101 equidistant transects across the length of a site. Labeling includes the name of the major transect. For example the thalweg transects between (and including) major transects A and B would be labeled as follows: A0, A1, A2, A3, A4, A5, A6, A7, A8, A9, B0 (i.e.., thalweg transect A0 is identical to major transect A)

Personnel Responsibilities

This method is performed by 2 or more persons. Staff performing this method must have been trained.

Equipment, Reagents, Supplies

- GPS
- *GPS Positions Form*
- Measuring rod
- 50-m tape
- Flagging
- Permanent marker
- Laser rangefinder
- Soft-lead pencil
- *Site Verification Form*
- Wading gear
- No. 2 pencil
- Maps

Summary of Procedure

The crew first navigates to the site using the coordinates provided by the Master Sample. They then verify that they are at the correct location and determine if the site is suitable for sampling. Next, they define the upper and lower boundaries and they define the transects within the site.

Establish the Data Collection Event

Prior to leaving the office, refer to the *GPS Positions Form* (Figure A-1). Enter the SITE_ID portion of the DCE using a number 2 pencil. Enter the Master Latitude and Master Longitude as listed on the Master Sample file.

Navigate to the site using the GPS receiver. Upon arrival, record the date (MMDD) and time (military) portion of the DCE. Record the GPS-measured coordinates for the Index Station. Identify the bank at which these coordinates were measured (left and right are interpreted when facing downstream). Also note the precision of the GPS measurement. Other notes on location can also be recorded. Record the turn-by-turn directions taken to reach the site's access point.

Reviewed by (Initials): FW

Status and Trends Program - GPS Positions Form

Site Number / YY / MMDD / HH / MM

DCE: W A M 0 6 0 0 - 0 0 0 0 1 8 - D C E - 2 0 0 9 - 0 8 1 5 - 0 9 : 0 0

Station	Bank (circle one)	Master Lat dec deg e.g. 47.123456	Master Lon dec deg e.g. 120.123456	GPSlatDD e.g. 47.123456	GPSLonDD e.g. 120.123456	Accuracy	Accuracy Units (ft, EPE, etc.)	Flag
INDEX STATION	L R	46.62843992	-122.04131986	46.62844	-122.04132	3	meters	
A0	L R			46.62770	-122.04160	3	meters	
B0	L R							
C0	L R							
D0	L R							
E0	L R							
F0	L R			46.62844	-122.04132	3	meters	
G0	L R							
H0	L R							
I0	L R							
J0	L R							
K0	L R			46.6290	-122.0410	3	meters	
PUTIN	L R							
TAKEOUT	L R							

ALL COORDINATES TO BE RECORDED IN NAD83

Position comments including accuracy: Index station is at transect F0

Directions to access point: From Hwy 706 in Ashford, drive south on FR26 for 10 miles. Hike west about 0.5 miles (no trail).

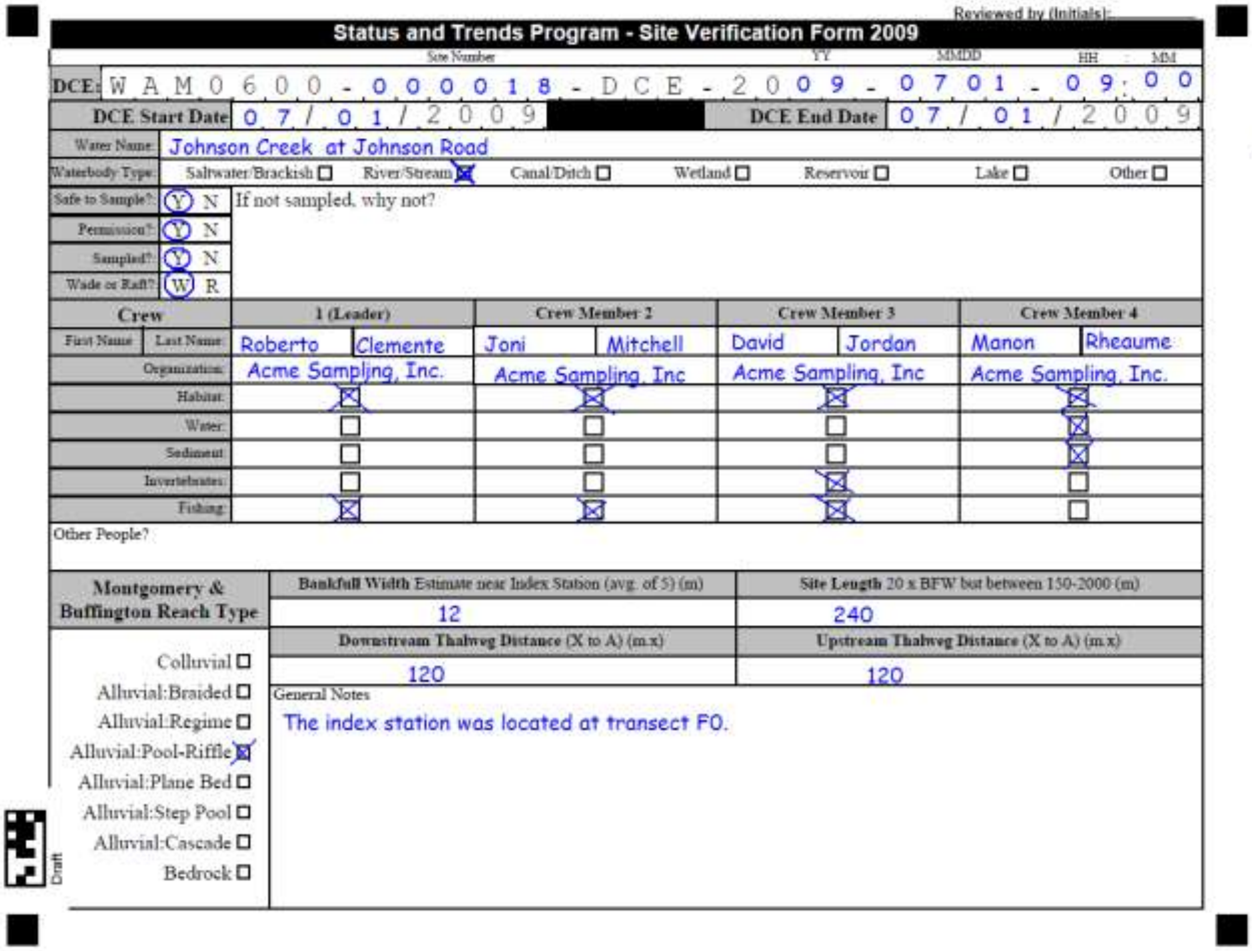
Draft

Figure A-1. The *GPS Positions Form* with example data.

Note: Sometimes streams have re-routed after production of the map from which the Master coordinates were generated. In these cases navigate to the closest (most representative) point on the stream.

Determine Site Suitability

After arrival and recording the DCE, determine whether the site is suitable for sampling. Refer to the *Site Verification Form* (Figures A-2, and A-3).


Reviewed by (Initials):

Status and Trends Program - Site Verification Form 2009

DCE: WAM06600-000018-DCE-2009-0701-09:00 (Site Number / YY / MMDD / HH : MM)

DCE Start Date: 07/01/2009 — DCE End Date: 07/01/2009

Water Name: Johnson Creek at Johnson Road

Waterbody Type: Saltwater/Brackish ☐ River/Stream ☒ Canal/Ditch ☐ Wetland ☐ Reservoir ☐ Lake ☐ Other ☐

Safe to Sample?: (Y) N — If not sampled, why not?

Permission?: (Y) N

Sampled?: (Y) N

Wade or Raft?: (W) R

Crew	1 (Leader)		Crew Member 2		Crew Member 3		Crew Member 4	
First Name / Last Name	Roberto	Clemente	Joni	Mitchell	David	Jordan	Manon	Rheaume
Organization	Acme Sampling, Inc.		Acme Sampling, Inc		Acme Sampling, Inc		Acme Sampling, Inc.	
Habitat	☒		☒		☒		☒	
Water	☐		☐		☐		☒	
Sediment	☐		☐		☐		☒	
Invertebrates	☐		☐		☒		☐	
Fishing	☒		☒		☒		☐	

Other People?

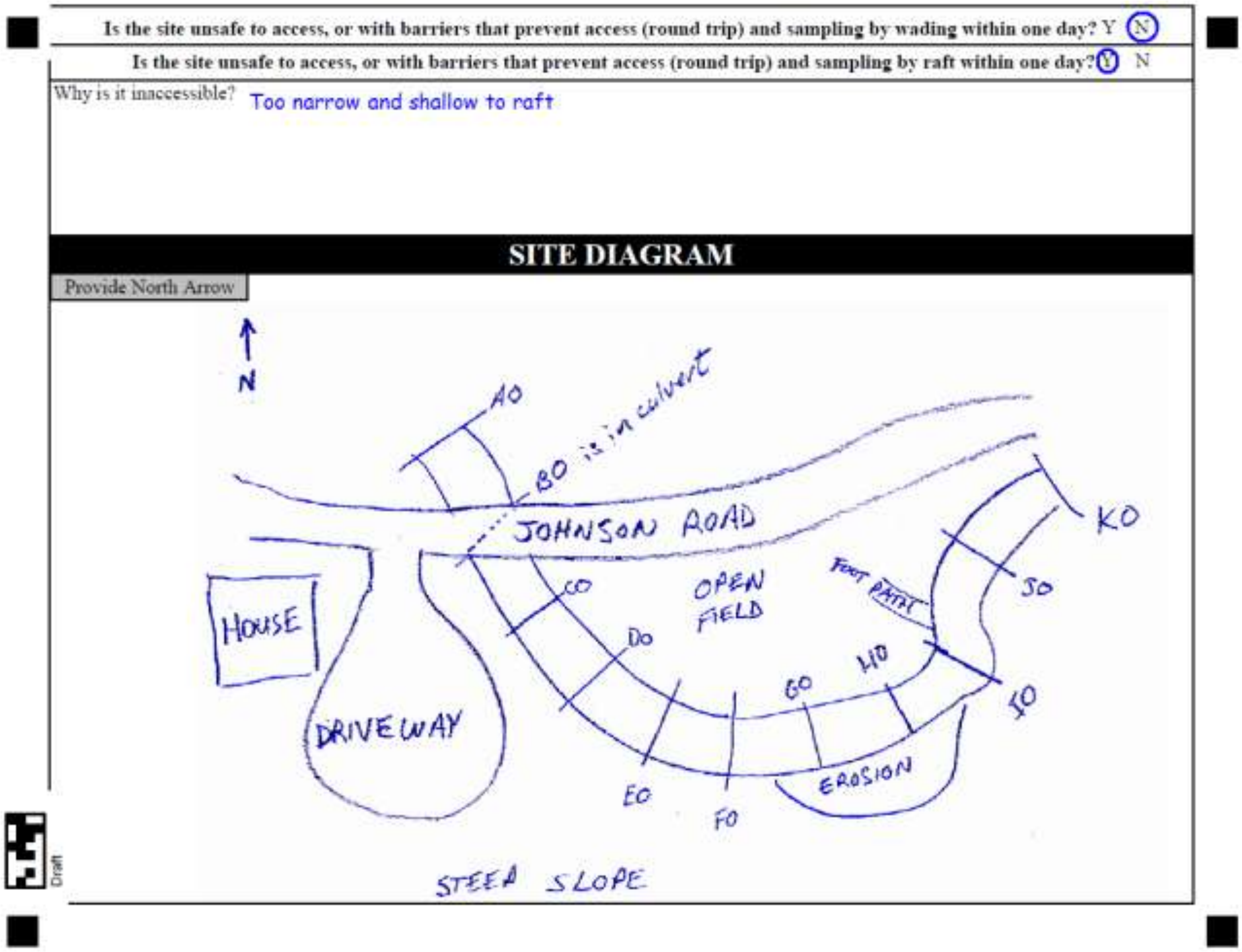
Montgomery & Buffington Reach Type	Bankfull Width Estimate near Index Station (avg. of 5) (m)	Site Length 20 x BFW but between 150-2000 (m)
	12	240
	Downstream Thalweg Distance (X to A) (m.x)	Upstream Thalweg Distance (X to A) (m.x)
	120	120

Colluvial ☐
Alluvial:Braided ☐
Alluvial:Regime ☐
Alluvial:Pool-Riffle ☒
Alluvial:Plane Bed ☐
Alluvial:Step Pool ☐
Alluvial:Cascade ☐
Bedrock ☐

General Notes: The index station was located at transect F0.

Draft

Figure A-2. The front side of the *Site Verification Form* with example data.



Is the site unsafe to access, or with barriers that prevent access (round trip) and sampling by wading within one day? Y N

Is the site unsafe to access, or with barriers that prevent access (round trip) and sampling by raft within one day? Y N

Why is it inaccessible? Too narrow and shallow to raft

SITE DIAGRAM

Provide North Arrow

Figure A-3. The back side of the *Site Verification Form*, with example data.

Desktop evaluation of the site was performed earlier according to the method described elsewhere in this protocol. Verify that conditions at the site are truly suitable for sampling during the day of arrival. Complete the appropriate fields in the top third of the front side of the *Site Verification Form,* indicating whether the site is being sampled, and if so, whether this is by wading or by rafting. The site should not be sampled if it is deemed:

- Unsafe to enter
- To have permission denied by land owners
- Not a stream or river (e.g. a wetland, lake)
- Not freshwater
- Within an artificial channel (e.g. canal or ditch)
- Not perennial
- Not with surface flow for more than 50% of the length.

Record Event Information

Next, on the *Site Verification Form* (Figure A-2), record the information below about the data collection event

Crew

Record the names of those who are in the crew. Also note the organization that each staff represents. The crew lead will be recorded in column 1. Staff sampling roles can be recorded later, after the day is done, by using the check boxes provided on the form.

Site

Bankfull Stage

Near the Index Station (X), visually estimate the bankfull stage. This is best done after considerable training. There are at least three good on-line sources of training materials for identifying bankfull stage:

1. http://preview.tinyurl.com/8aabbm (Buffington, 2007)
2. http://www.dnr.wa.gov/Publications/fp_bfw_video_pt1.wmv
   http://www.dnr.wa.gov/Publications/fp_bfw_video_pt2.wmv (Grizzel, 2008)
3. http://www.stream.fs.fed.us/publications/bankfull_west.html (Leopold et al, 1995)

Bankfull stage height is *not* a value that gets recorded on the *Site Verification Form*. The crew merely uses their visual estimate to help understand where to measure bankfull width.

Bankfull Width

Using the estimated bankfull level, measure the channel width at each of 5 transects near the Index Station:

1. The Index Station (X)
2. 1 bankfull width upstream from X
3. 2 bankfull widths upstream from X
4. 1 bankfull width downstream from X
5. 2 bankfull widths downstream from X

Record the average (nearest meter) of these 5 bankfull width measurements on the *Site Verification Form* (Figure A-2). Width measurements can be made using either a 50-m tape, a measuring rod, or (if the channel is wide) with a laser rangefinder.

Site Length

Sites must be no shorter than 150 m and no longer than 2000 m. Multiply the average bankfull width times 20. This value (whole meters) is the site length for a path that follows the main flow of the river. However, for any site with bankfull width less than 8 meters, the site length will be extended to 150 m; for any site with bankfull width over 100 m, reduce the length to 2000 m. Record the site length on the *Site Verification Form* (Figure A-2).

Sampling methods for waded streams are restricted to sites that are less than 25 meters wide (less than 500 m long). Larger sites can be waded if shallow, but will be sampled using raft protocols This rule will allow sampling on large streams to be accomplished within a single work day.

Relative position of the Index Station (X) within the site

The index station (X) is normally located at the middle of the site (i.e. at major transect F). On the *Site Verification Form* (Figure A-2), record the distance (tenths of meters) from X to the bottom of the site (i.e., to major transect A) and the distance from X to the top of the site (i.e., to major transect K). This distance is measured along the thalweg channel. Unless there is a reason to adjust the position of X, the distance will be equal to half the site length, in each direction.

The relative position of X can be adjusted for reasons such as

- to keep the top or bottom of the site in lands where permission has not been denied, or
- to keep from changing Strahler stream order (at the 1:100,000 scale), or
- to account for barriers such as lakes.

The location of the Index Station's coordinates can never be changed. These are pre-defined by the survey design. Although the site position can change relative to X (called "sliding" the site), the site must always contain X.

Bed Form

Assess the site for its predominant reach type according to Montgomery and Buffington (1993, 1997). Review the source materials hot-linked in the references to help understand the differences between bed forms. These references discuss details and provide images of examples.

First decide whether the site is predominated by a reach that is colluvial, alluvial, or bedrock. Colluvial streams have a low chance of being sampled by this Status and Trends program, because we are limiting our sample to perennial streams. Bedrock streams are confined locations with little depositional material present. Most streams sampled will be alluvial.

Next, if the site is predominantly alluvial, decide which one of the following sub-classifications can be used to describe the site.

- cascade
- step-pool
- plane-bed
- pool-riffle
- regime
- braided

Place an X in the appropriate box of the *Site Verification Form* (Figure A-2) to describe the predominant bed form within the site. Refer to the references (Montgomery and Buffington, 1993, 1997, 1998) and the definitions table (Table A-1) for help. Figures A-4 and A-5 might help.

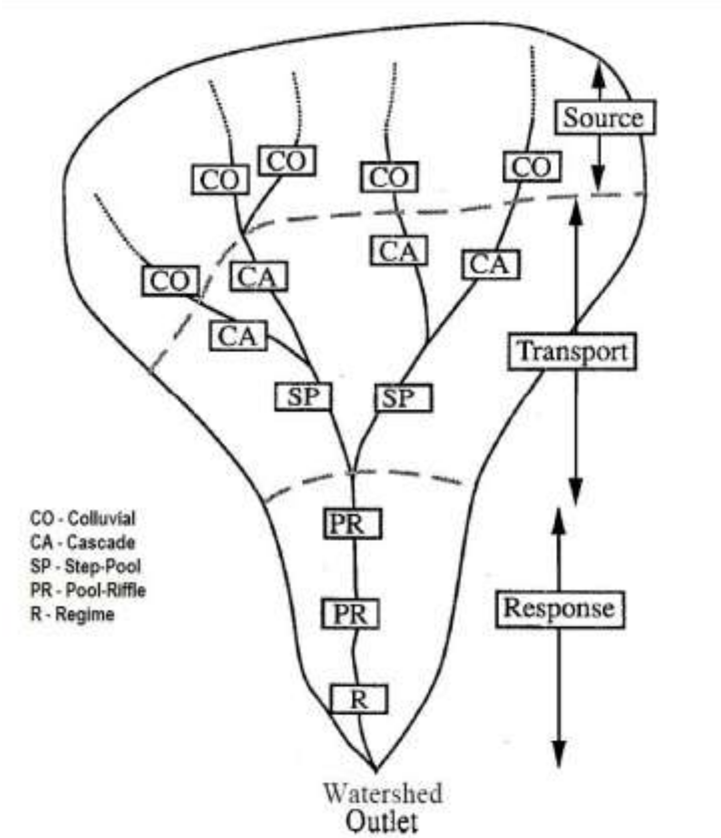


Figure A-4. Idealized positions (aerial view) of bed form types within a watershed. Modified from figure 22 of Montgomery and Buffington (1993).

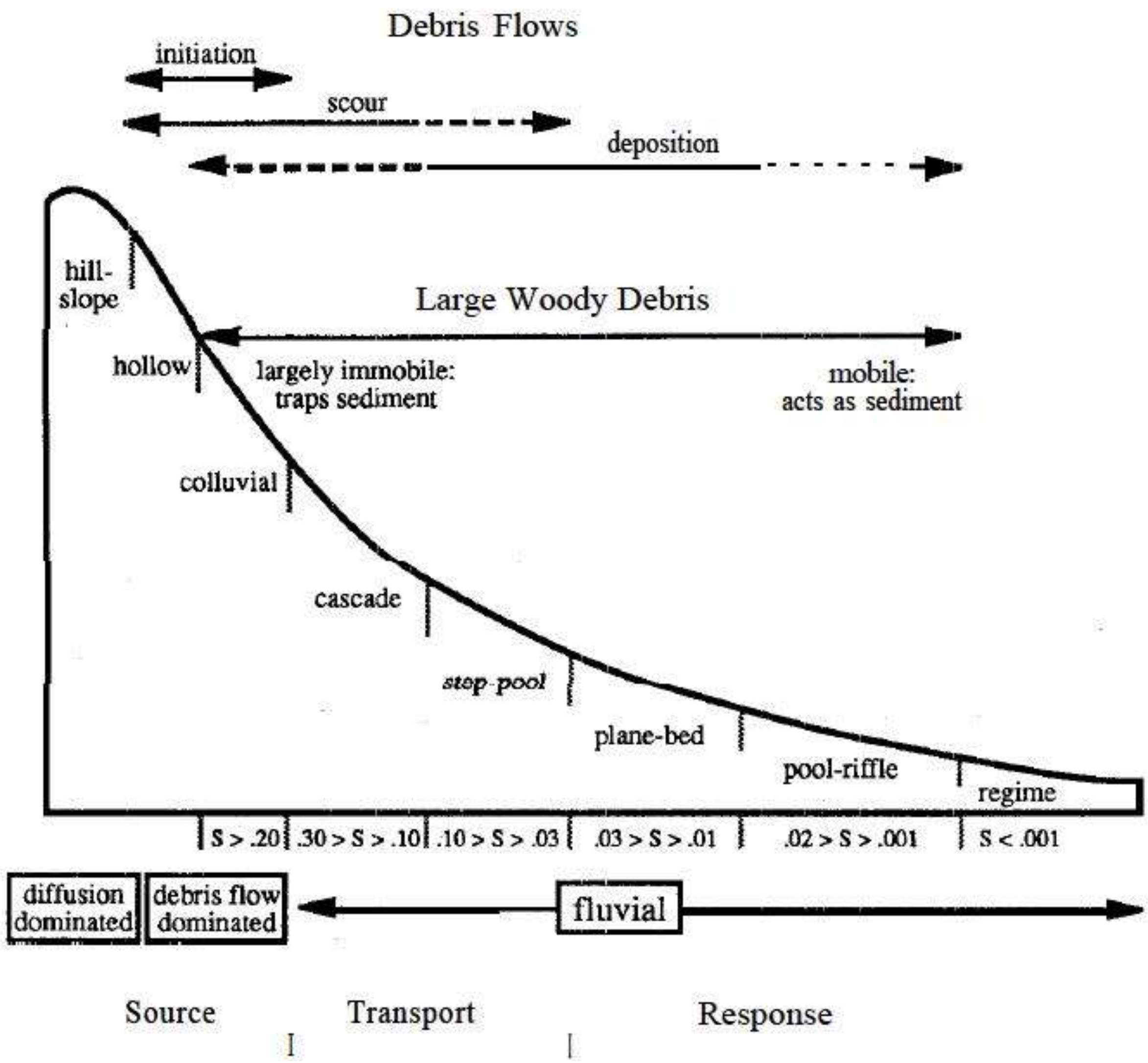


Figure A-5. Idealized positions (plan view) of bed form types within a watershed (from figure 16 of Montgomery and Buffington (1993)).

Layout the Reach

There are 3 types of transects that define the stream site (Table A-2): thalweg transects, major transects and minor transects.

Thalweg Transects

Conceptually divide the stream site length using 101 transects which are perpendicular to the thalweg. These are called Thalweg Transects. They occur at regular intervals (0.2 bankfull widths). Thalweg transects, except for those that are also major transects (see below), do not need to be marked. Thalweg transects are useful in concept for describing relative positions within the site.

Major transects

Use orange flagging and a permanent marker to mark each of the 11 equidistant major transects. The lowest is *transect A0*, the highest is *transect K0*. Measure the distance between transects using either a 50-m tape or a measuring rod, by following the thalweg of the stream. The distance between flags should be $1/10^{th}$ of the site length or (or 2 times the estimated bankfull width at the index station).

Minor Transects

Ten minor transects occur mid-way between the 11 major transects (Table A-2) The distance between major and minor transects is $1/5^{th}$ the site length (or 1 bankfull width). Minor transects don't need to be marked.

Table A-2. The relative position of all transects on a stream site.

Station	Thalweg Transect	Major Transect	Minor Transect	Distance from Bottom (Bankfull Widths*)
A0	Yes	Yes		0
A1	Yes			0.2
A2	Yes			0.4
A3	Yes			0.6
A4	Yes			0.8
A5	Yes		Yes	1
A6	Yes			1.2
A7	Yes			1.4
A8	Yes			1.6
A9	Yes			1.8
B0	Yes	Yes		2
B1	Yes			2.2
B2	Yes			2.4
B3	Yes			2.6
B4	Yes			2.8
B5	Yes		Yes	3
B6	Yes			3.2
B7	Yes			3.4
B8	Yes			3.6
B9	Yes			3.8
C0	Yes	Yes		4
C1	Yes			4.2
C2	Yes			4.4
C3	Yes			4.6
C4	Yes			4.8
C5	Yes		Yes	5
C6	Yes			5.2
C7	Yes			5.4
C8	Yes			5.6
C9	Yes			5.8
D0	Yes	Yes		6
D1	Yes			6.2
D2	Yes			6.4
D3	Yes			6.6
D4	Yes			6.8
D5	Yes		Yes	7
D6	Yes			7.2
D7	Yes			7.4

D8	Yes			7.6
D9	Yes			7.8
E0	Yes	Yes		8
E1	Yes			8.2
E2	Yes			8.4
E3	Yes			8.6
E4	Yes			8.8
E5	Yes		Yes	9
E6	Yes			9.2
E7	Yes			9.4
E8	Yes			9.6
E9	Yes			9.8
F0	Yes	Yes		10
F1	Yes			10.2
F2	Yes			10.4
F3	Yes			10.6
F4	Yes			10.8
F5	Yes		Yes	11
F6	Yes			11.2
F7	Yes			11.4
F8	Yes			11.6
F9	Yes			11.8
G0	Yes	Yes		12
G1	Yes			12.2
G2	Yes			12.4
G3	Yes			12.6
G4	Yes			12.8
G5	Yes		Yes	13
G6	Yes			13.2
G7	Yes			13.4
G8	Yes			13.6
G9	Yes			13.8
H0	Yes	Yes		14
H1	Yes			14.2
H2	Yes			14.4
H3	Yes			14.6
H4	Yes			14.8
H5	Yes		Yes	15
H6	Yes			15.2
H7	Yes			15.4
H8	Yes			15.6
H9	Yes			15.8

I0	Yes	Yes		16
I1	Yes			16.2
I2	Yes			16.4
I3	Yes			16.6
I4	Yes			16.8
I5	Yes		Yes	17
I6	Yes			17.2
I7	Yes			17.4
I8	Yes			17.6
I9	Yes			17.8
J0	Yes	Yes		18
J1	Yes			18.2
J2	Yes			18.4
J3	Yes			18.6
J4	Yes			18.8
J5	Yes		Yes	19
J6	Yes			19.2
J7	Yes			19.4
J8	Yes			19.6
J9	Yes			19.8
K0	Yes	Yes		20

* For very small or very large sites (with length of 150 m or 2000 m), the transect spacing is 1/100the of the site length, and might not be 0.2 bankfull widths.

Record Coordinates

Refer to *GPS Positions Form* (Figure A-1). Record the GPS-measured coordinates at the bottom of the site (transect A0), and at the top of the site (transect K0). Note the bank at which the GPS was used and the accuracy of the measurements. You might also record coordinates for other major transects too, but this is not required for the waded streams.

References

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Grizzel, J. 2008. Washington State Department of Natural Resources, Forest Practices Board. Olympia, WA. *Identifying Bankfull Channel Edge* (Parts 1 (1 min 52 sec) and 2 (9 min 6 sec)). http://www.dnr.wa.gov/BusinessPermits/Topics/ForestPracticesRules/Pages/fp_board_manual.aspx.

Leopold, L.B. W.W. Emmett, H.L. Silvey, and D. L. Rosgen. 1995. *A Guide for Field Identification of Bankfull Stage in the Western United States*. Online video (31 minutes, closed captioned). Stream Systems Technology Center USDA, Forest Service, Rocky Mountain Research Station, Fort Collins, CO.
http://www.stream.fs.fed.us/publications/videos.html#eastandwest

Montgomery, D.R., and J.M. Buffington. 1993. *Channel Classification, Prediction of Channel Response and Assessment of Channel Condition, Washington State.* TFW-SH10-93-002. http://www.krisweb.com/biblio/gen_wadnr_montgomeryetal_1993_tfwsh1093002.pdf

Montgomery, D.R. and J.M. Buffington. 1997. *Channel-reach morphology in mountain drainage basins*. Geological Society of America Bulletin, 109(5):596-611. http://www.esm.ucsb.edu/academics/courses/235/Readings/Montgomery+Buffington%201997%20GSA.pdf

Montgomery, D.R., and J.M. Buffington, 1998, *Channel processes, classification, and response*, in River Ecology and Management, edited by R. Naiman and R. Bilby, Springer-Verlag, New York, NY, pp. 13-42.
http://www.fs.fed.us/rm/boise/publications/watershed/rmrs_1998_montomeryr001.pdf

Appendix B

Quality Control for *In Situ* Meters

Purpose and Scope

This method explains how to verify that *in situ* meters used for the Status and Trends Program are working properly. Instruments included on the procedure include probes for measuring temperature, pH, conductivity, and dissolved oxygen (Minisonde Multiprobes) It also includes the instrument used for measuring water velocity (Marsh-McBirney FloMate-2000).

Definitions

Definitions of acronyms and other terms are found in Table B-1.

Table B-1. Definitions.

Term or Accronym	**Definition**
DCE	Data Collection Event. Data are indexed using this code which includes the SITE_ID, the date, and the time that the event began.
NIST	National Institute of Standards and Technology
QC	Quality control. A quality control check is a measurement of a standard value to estimate the accuracy of an instrument.
QCCS	A quality control standard suitable for assessing errors of pH and conductivity of dilute neutral pH waters (Metcalf and Peck 1993). A dilute phosphate standard is prepared as a 100-fold dilution KH_2PO_4 and Na_2HPO_4 standard buffer solution (NIST pH buffer 6.865). It has a theoretical **pH value of pH 6.98** and calculated **conductivity value of 75.3 µS cm^{-1} at 25 °C**. The stock solution should be kept refrigerated, but the 1:100 dilution should have no detectable change in pH or conductivity for at least 15 months when stored in polyethylene containers between 10-40 ^{o}C.
Sonde	The cylindrical portion of the Hydrolab. It contains the sensors.
Surveyor	The control and display portion of the Hydrolab.

Personnel Responsibilities

This method is performed by 1 or more persons. This method is applied at every DCE, before and after sampling, although some of the tasks are required less frequently. Staff performing this method must have been trained.

Equipment, Reagents, Supplies

- No. 2 pencil
- Calibration Form
- Flow Meter
- Flow Meter batteries
- Wading rod
- Flow Meter Manual (Marsh-McBirney, 1990)
- Five-gallon bucket (for flow meter zero-adjust)
- Hydrolab, components, maintenance kit (Swanson, 2007)
- Hydrolab Manuals (Hach 1999, Hach 2006a, Hach 2006b)
- QCCS (Metcalf and Peck 1993)
- pH 7 buffer (7.00) – e.g. VWR - 23197-996
- pH 4 buffer (4.01) – e.g. VWR - 23197-998
- pH 10 buffer (10.01) – e.g. VWR - 23197-994
- pH 7 standard (6.97) – e.g. Thermo 700702
- pH 4 standard (4.10) – e.g. Thermo 700402
- pH 9 standard (9.15) – e.g. Thermo 700902
- Conductivity Standard (100 µS) – e.g. VWR 23226-589
- Conductivity Standard (1,000 µS) – e.g. VWR 23226-603
- Conductivity Standard (alternate as available)
- De-ionized water (DI)
- Tap Water
- Lab tissues (e.g. KimWipes®)
- Barometer
- Winkler sampling supplies (see Mathieu 2007)

Summary of Procedure

Calibrate (Conductivity, pH, Dissolved Oxygen, and Velocity)

Use the *Calibration Form* (Figure B-1) to record calibrations and quality control checks. Each day calibrate conductivity (COND), pH, dissolved oxygen (DO) and velocity. The DO should be calibrated on-site or near the site, to match local barometric pressure of calibration and sampling. The pH and conductivity calibration standards should be chosen to bracket expected values. For example, most wadeable streams west of the Cascades or in moderate to high elevations will need to be calibrated with pH 7 and pH 4 standards, they will need to be calibrated with 0 and 100 µS conductivity standard. Many larger streams and rivers will need to be calibrated with pH 7 and ph 10 standards. Some rivers might need to be calibrated with 0 and > 100 µS conductivity standards.

The order of calibration is normally

1) COND (Hydrolab),
2) pH (Hydrolab),
3) DO (Hydrolab), then
4) Velocity (zero-adjust the flow meter).

Before calibrating, make sure that a post-sampling QC check measurement has been made to verify the quality of sampling at the previously sampled site. QC checking is discussed in detail later in this document.

S&T Calibration Form prototype			Comments
Person Calibrating Hydrolab			
Date			
Hydrolab Sonde serial number			
Hydrolab Sonde Battery Voltage			
Hydrolab Surveyor serial number			
Hydrolab Surveyor Battery Voltage			
Flow Meter serial number			
Conductivity Calibration			
Standard Used Check one	100 ☐ 1000 ☐		
Cond. (before adjusting)		µS/cm at 25˚C	
Cond. (after adjusting)		µS/cm at 25˚C	
Standard's Temperataure (˚C)		˚C	
QCCS Cond. (pre-field)		units	
QCCS temperature (pre-field)		˚C	
QCCS (pre-field) 65.3 to 85.3 µS/cm at 25˚C ?	Yes ☐ No ☐		No means "failed" - recalibrate
QCCS Cond. (post-field)		units	
QCCS temperature (post-field)		˚C	
QCCS date (post-field)		mm/dd/yyyy	
QCCS (post-field) 65.3 to 85.3 µS/cm at 25˚C ?	Yes ☐ No ☐		No means "failed" - qualify data
QCCS batch check		µS/cm at 25˚C	
QCCS batch check		˚C	
QCCS batch check		mm/dd/yyyy	
pH Calibration			
Standards Used: 6.95 and (Check one)	4.10 ☐ 9.15 ☐	OR	
7 and (Check one)	4 ☐ 10 ☐		
pH 6.95 or pH 7 temperature		˚C	
pH 6.95 or pH 7 value - before adjusting		units	
pH 6.95 or pH 7 value - after adjusting		units	
Temp. of 2nd pH standard after adjusting		˚C	
pH of 2nd standard pH - before adjusting		units	
pH of 2nd standard pH - after adjusting		units	
Calibration Slope		%	
Calibration Slope >90% (for dilute standards)	Yes ☐ No ☐	4.10,6.95,9.15	No means "failed" - recalibrate
Calibration Slope > ___% (for buffer standards)	Yes ☐ No ☐	4,7,10	No means "failed" - recalibrate
QCCS pH (pre-field)		units	
QCCS temperature (pre-field)		˚C	
QCCS -(pre-field) 6.78 to 7.18 ?	Yes ☐ No ☐		No means "failed" - recalibrate
QCCS pH (post-field)		units	
QCCS temperature (post-field)		˚C	
QCCS date (post-field)		mm/dd/yyyy	
QCCS -post 6.78 to 7.18 ?	Yes ☐ No ☐		No means "failed" - qualify data
QCCS batch check		units	
QCCS batch check		˚C	
QCCS batch check		mm/dd/yyyy	
DO Calibration			
Atmospheric Pressure		mm HG	
Altitude		ft	
Calibration Temperataure		˚C	
Reading-DO		mg/L	
Reading-Percent Saturation		%	
QCC-Winkler reading		mg/L	
QCC-person titrating			
QCC-Winkler within 0.4 mg/L of Hydrolab	Yes ☐ No ☐		No means "failed" - qualify data
Temperature Calibration check			
Ice bath - Hydrolab		˚C	
Ice bath - NIST Thermometer		˚C	
Ice bath - measures within 1 ˚C	Yes ☐ No ☐		No means "failed" - qualify data
Warm bath - Hydrolab		˚C	
Warm bath - NIST Thermometer		˚C	
Warm bath - measures within 1 ˚C	Yes ☐ No ☐		No means "failed" - qualify data
Person checking			
Velocity Zero-adjust			
At zero in bucket?	Yes ☐		
Adjustment necessary?	Yes ☐ No ☐		
Person checking flow meter			

Figure B-1. The Calibration Form.

Clean the Hydrolab Sonde and the Flow Meter Sensor

Refer to Swanson (2007) section 6.3 and to Marsh-McBirney 1990.

Rinse Hydrolab Sonde between each operation

Rinse three times with tap water, three times with deionized water, then three times with the solution to be used for calibrating or testing.

Calibrate conductivity to bracket expected field conductivity

1. Dry the conductivity probe with a lab tissue (e.g. KimWipe®).
2. Using the Surveyor, enter 0 into SpCond, to dry calibrate to 0
3. Fill the calibration cup to within a centimeter of the top of the calibration cup with dilute standard (either 100 µS or 1,000 µS) so that the probes are covered.
4. Make sure there are no bubbles in the cell, wait 2 minutes.
5. Using the Surveyor, enter the appropriate value for the standard into SpCond.

Calibrate pH to bracket expected field pH

1. Pour the pH 7 buffer into the calibration cup to cover the sensor and reference electrode. Enter the theoretical pH value units the Surveyor. Theoretical values are based on temperature of the standard and are listed in Table B-2.
2. Rinse and repeat step 1, using either the pH 10 buffer (when sampling in basic waters) or pH 4 buffer (when sampling in acidic waters).
3. On the calibration form, record the temperature and theoretical pH values that were used to calibrate. Also record adjustments that were needed to calibrate to these theoretical values.
4. On the calibration form, record the percent slope of the calibration (displayed on the Surveyor). Be sure this percent slope matches the criteria described on the form. Otherwise, recalibrate.

Table B-2. Theoretical pH values by temperature for each pH standard buffer.

Temp (˚C)	**4[a]**	**7[b]**	**10[c]**
4	4.00	7.09	10.26
5	4.00	7.08	10.25
6	4.00	7.08	10.23
7	4.00	7.07	10.22
8	4.00	7.07	10.21
9	4.00	7.06	10.2.0
10	4.00	7.06	10.18
11	4.00	7.05	10.17
12	4.00	7.05	10.16
13	4.00	7.04	10.14
14	4.00	7.04	10.13
15	4.00	7.03	10.12
16	4.00	7.03	10.11
17	4.00	7.02	10.10
18	4.00	7.02	10.09
19	4.00	7.02	10.08
20	4.00	7.01	10.06
21	4.01	7.01	10.05
22	4.01	7.01	10.04
23	4.01	7.00	10.03
24	4.01	7.00	10.02
25	4.01	7.00	10.01
26	4.01	6.99	10.00
27	4.01	6.99	9.99
28	4.01	6.99	9.98
29	4.01	6.99	9.98
30	4.02	6.98	9.97

Buffers: [a] Thermo 7.00, [b] Thermo 4.01, [c] Thermo 10.01.

From: www.thermo.com/com/cda/resources/resources_detail/1,2166,13217,00.html

Calibrate DO using water-saturated air

1. Fill the calibration cup with about 1/2 inch of DI; it should be below the sensor cap.
2. Use Kimwipes to dry any droplets from the sensor cap.
3. Invert calibration cup's cap and gently rest it on the cup.
4. Wait 5 minutes, making sure that temperature stabilizes.
5. Determine local barometric pressure (mm Hg) and enter this value into the Surveyor.
6. Click "Calibrate". A "Calibrate Successful" will be displayed.

.

DO calibration notes:

1) To retain calibration accuracy between measurements, store with the sensor immersed in water or within a water-saturated air environment such as a sealed storage cup with at least 10 ml of water.
2) It is important to have the water-saturated air and the sensor at the same temperature. Therefore, store a jar of DI in the same environment as the sonde, and calibrate in a similar air temperature as the water and sonde.
3) Stay out of direct sun or wind.
4) Refer to Table B-3 if necessary.

Table B-3 unit conversions for pressure.

Atmospheres	Bars	mm Hg	inches Hg
1	1.01325	760	29.92126
0.9869233	**1**	750.0617	29.52999
0.001315789	0.001333224	**1**	0.03937008
0.03342105	0.03386388	25.4	**1**

Zero-Adjust the Flow Meter

Zero the flow meter prior to each use. Refer to Marsh-McBirney 1990 (pages 8-9).

Quality Control

Daily Checks

Check pH and conductivity at the start and end of each DCE by measuring the QCCS. Record the temperature of the QCCS too. The **pH should measure between 6.78 and 7.18 pH units**. **Conductivity should measure between 65.3 and 85.3 µS/cm at 25 ˚C**. Re-calibrate if the pre-sampling check fails these criteria. Data from the DCE should be qualified if the post-sampling check fails these criteria. Record measurements on the *Calibration Form*

Monthly Checks

Once monthly, check the accuracy of the DO sensor on the Hydrolab. Collect a Winkler sample at the same location and time as an *in situ* DO reading. Winkler samples are collected and analyzed according to Mathieu (2007).

Twice-seasonal checks

Before and after the season, check the regular pH calibrations against dilute pH standards:
- pH 7 standard (6.97) – e.g. Thermo 700702
- pH 4 standard (4.10) – e.g. Thermo 700402
- pH 9 standard (9.15) – e.g. Thermo 700902

Calibrate first with the regular buffers as for the daily calibrations (e.g. first 7 and 4), then check using the QCCS. Re-calibrate, this time using the dilute standards (e.g. 6.97 and 4.10). Measure the QCCS and compare the difference in QCCS measures between calibrations. Repeat for the high-pH calibrations (7 and 10; 6.97 and 9.15). Theoretical values by temperature for the dilute pH standards are found in Table B-4.

The Hydrolab's thermistor is factory calibrated. Check the settings before and after the field season by comparing with an NIST-traceable thermometer. Verify that it measures to within 1˚ C the thermometer. Do this in an ice water bath and in a warm water bath. Qualify the season's temperature data if the measures fall outside this range.

Table B-4. Theoretical values by temperature for the dilute pH standards

Temp (˚C)	4[a]	7[b]	9[c]
10	**4.10**	**7.01**	**9.27**
11	**4.10**	**7.01**	**9.26**
12	**4.10**	**7.00**	**9.25**
13	**4.10**	**7.00**	**9.25**
14	**4.10**	**7.00**	**9.24**
15	**4.10**	**7.00**	**9.23**
16	**4.10**	**6.99**	**9.22**
17	**4.10**	**6.99**	**9.21**
18	**4.10**	**6.99**	**9.21**
19	**4.10**	**6.98**	**9.20**
20	**4.10**	**6.98**	**9.19**
21	**4.10**	**6.98**	**9.18**
22	**4.10**	**6.97**	**9.18**
23	**4.11**	**6.97**	**9.17**
24	**4.11**	**6.97**	**9.16**
25	**4.11**	**6.97**	**9.16**
26	**4.11**	**6.96**	**9.15**
27	**4.11**	**6.96**	**9.14**
28	**4.12**	**6.96**	**9.13**
29	**4.12**	**6.95**	**9.13**
30	**4.12**	**6.95**	**9.12**

[a] Orion 700402, [b] Orion 700702, [c] Orion 700902

References

Hach Company. 1999. Surveyor® 4 Water Quality Display User's Manual. HL#003070, REVISION B.

Hach Company. 2006a. Hydrolab DS5X, DS5, and MS% Water Quality Multiprobes, User manual, February 2006, Edition 3. http://www.hydrolab.com/pdf/S5_Manual.pdf

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Mathieu, N. 2007. Standard Operating Procedure for Measuring Dissolved Oxygen in Surface Water, Version 1.1. Washington Department of Ecology, Environmental assessment Program, Olympia, WA.
http://www.ecy.wa.gov/programs/eap/qa/docs/ECY_EAP_SOP_035MeasuringDO_v1_1.pdf

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Swanson, T. 2007. Standard Operating Procedures for Hydrolab® DataSonde® and MiniSonde® Multiprobes, Version 1.0. Washington Department of Ecology, Environmental assessment Program, Olympia, WA.
http://www.ecy.wa.gov/programs/eap/qa/docs/ECY_EAP_SOP_033Hydrolab.pdf

Appendix C

In Situ Measurements in Wadeable Streams

Purpose and Scope

This method explains how to collect *in situ* measures of temperature, dissolved oxygen, pH and conductivity at wadeable streams for the Status and Trends Program using a multi-probe (e.g. Hydrolab Minisonde).

It requires adherence to calibration techniques discussed elsewhere in this procedure.

Definitions

Definitions of acronyms and other terms are found in Table C-1.

Table C-1. Definitions.

Term or Accronym	**Definition**
DCE	Data Collection Event. Data are indexed using this code which includes the SITE_ID, the date, and the time that the event began.
index station	The point location mapped by the site coordinates. It is sometimes called "X". This is normally located at the mid-elevation of the stream site.
NIST	National Institute of Standards and Technology
QC	Quality control. A quality control check is a measurement of a standard value to estimate the accuracy of an instrument.
thalweg transect	There are 101 equally spaced thalweg transects dividing the length of the stream site. They are labeled A0, A1, A2,A3, A4, A5, A6, A7, A8, A9, B0,….K0. Transect A0 is at the bottom of the site. K0 is at the top.

Personnel Responsibilities

This method is performed by 1 or more persons. This method is applied at every DCE, at the start *and* end of the sampling event. Staff performing this method must have been trained.

Equipment, Reagents, Supplies

- No. 2 pencil
- Chemistry and Sampling Form
- Completed Calibration Form
- Hydrolab, components, maintenance kit (Swanson, 2007)
- Hydrolab Manuals (Hach 1999, Hach 2006a, Hach 2006b)

Summary of Procedure

Calibrate the instrument before sampling according to calibration methods discussed elsewhere in this protocol. Check the instrument after calibration, but before *and* after sampling, according to those same methods. Measure the stream twice.

Verify Quality Control

Prior to sampling

Ensure that the calibrations and that QC checks have been performed according to methods described elsewhere in this protocol. Circle "Yes" on the top section of the Chemistry and Sampling Form (Figure C-1) for each sensor that checked out. Proceed with measurements using sensors that are within criteria.

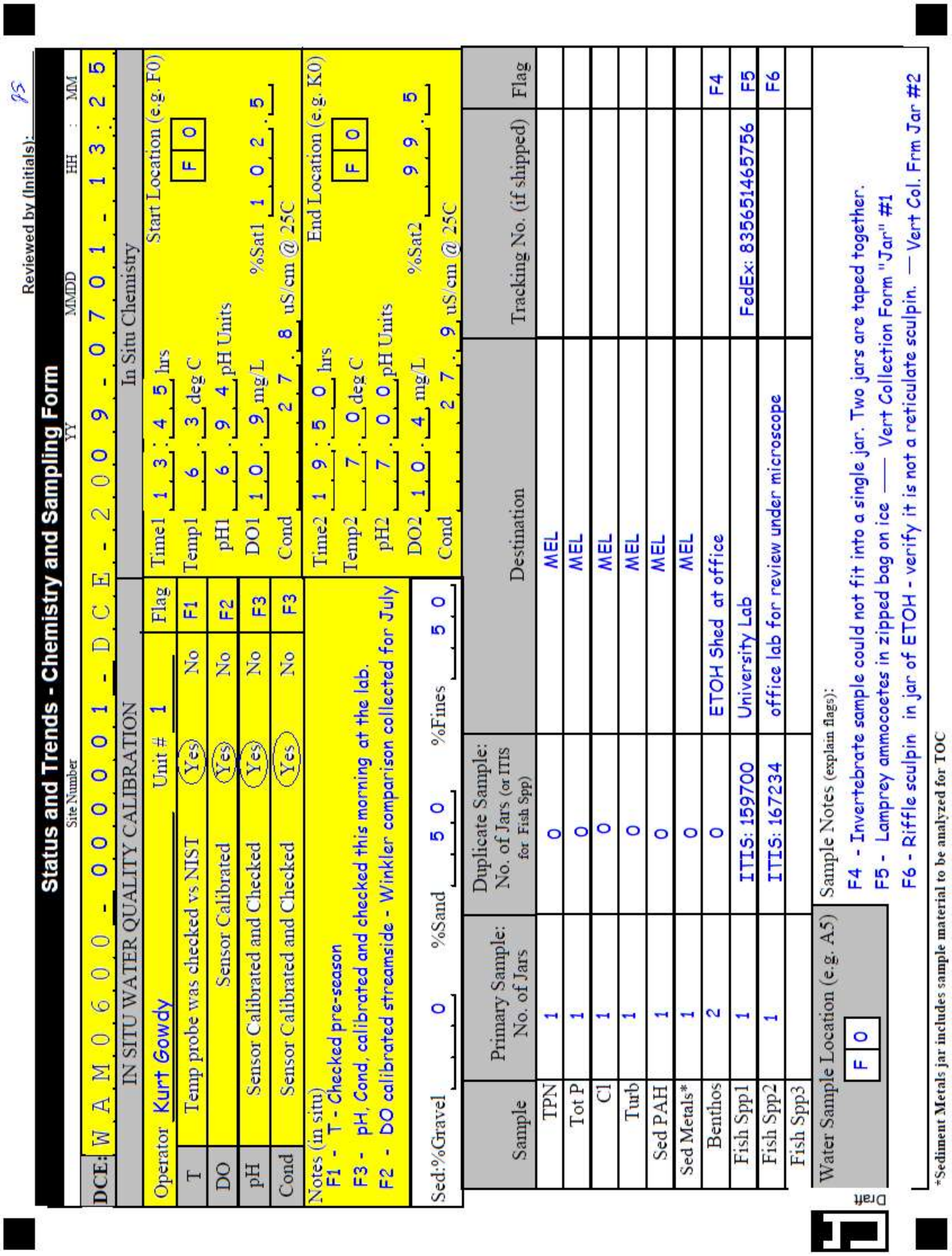
After sampling

Post-sampling calibration checks can be performed during the following day. Be sure to qualify data that were collected preceding calibration checks that failed to meet criteria.

Measure

Measure pH, water temperature, dissolved oxygen, oxygen percent saturation, and specific conductivity twice during a DCE, once at the start and once at the end. Record time (military) and location (thalweg transect). Both sets of in situ measurements should usually be made near the middle elevation of the site, on the main channel. Measurements should *always* be taken within the boundaries of the site (between transects A0 and K0).

Place the probes into the stream and let them thermally equilibrate to the stream temperature. This might take 3-5 minutes. Then hold the sensors so that they are just below the surface of the water, and completely immersed. Avoid any turbulence. Make sure that readings are stable. On the Chemistry and Sampling Form (figure E-1), record temperature (˚ C, nearest tenth), pH (pH unit, nearest hundredth), specific conductivity (µS/cm at 25˚ C, nearest tenth), dissolved oxygen (mg/L, nearest tenth), and oxygen percent saturation (nearest tenth).



Status and Trends - Chemistry and Sampling Form

Reviewed by (Initials): JS

DCE:	Site Number			YY	MMDD	HH : MM
	W A M 0 6 0 0 - 0 0 0 0 0 1	D C E		2 0 0 9	0 7 0 1	1 3 : 2 5

IN SITU WATER QUALITY CALIBRATION

Operator Kurt Gowdy		Unit # 1		Flag
T	Temp probe was checked vs NIST	Yes	No	F1
DO	Sensor Calibrated	Yes	No	F2
pH	Sensor Calibrated and Checked	Yes	No	F3
Cond	Sensor Calibrated and Checked	Yes	No	F3

Notes (in situ)
F1 - T - Checked pre-season
F3 - pH, Cond, calibrated and checked this morning at the lab.
F2 - DO calibrated streamside - Winkler comparison collected for July

Sed:%Gravel 0 %Sand 50 %Fines 50

In Situ Chemistry

Time1 13:45 hrs			Start Location (e.g. F0) F0
Temp1 6.3 deg C			
pH1 6.94 pH Units			
DO1 10.9 mg/L		%Sat1 102.5	
Cond 27.8 uS/cm @ 25C			
Time2 19:50 hrs			End Location (e.g. K0) F0
Temp2 7.0 deg C			
pH2 7.00 pH Units			
DO2 10.4 mg/L		%Sat2 99.5	
Cond 27.9 uS/cm @ 25C			

Sample	Primary Sample: No. of Jars	Duplicate Sample: No. of Jars (or ITIS for Fish Spp)	Destination	Tracking No. (if shipped)	Flag
TPN	1	0	MEL		
Tot P	1	0	MEL		
Cl	1	0	MEL		
Turb	1	0	MEL		
Sed PAH	1	0	MEL		
Sed Metals*	1	0	MEL		
Benthos	2	0	ETOH Shed at office		F4
Fish Spp1	1	ITIS: 159700	University Lab	FedEx: 835651465756	F5
Fish Spp2	1	ITIS: 167234	office lab for review under microscope		F6
Fish Spp3					

Water Sample Location (e.g. A5) F0

Sample Notes (explain flags):
F4 - Invertebrate sample could not fit into a single jar. Two jars are taped together.
F5 - Lamprey ammocoetes in zipped bag on ice —— Vert Collection Form "Jar" #1
F6 - Riffle sculpin in jar of ETOH - verify it is not a reticulate sculpin. — Vert Col. Frm Jar #2

*Sediment Metals jar includes sample material to be analyzed for TOC
Note: Use standard Manchester Environmental Lab forms for tracking water and sediment samples.

Draft

Figure C-1. The Chemistry and Sampling Form, with examples of *in situ* data records highlighted.

References

Hach Company. 1999. Surveyor® 4 Water Quality Display User's Manual. HL#003070, REVISION B.

Hach Company. 2006a. Hydrolab DS5X, DS5, and MS% Water Quality Multiprobes, User manual, February 2006, Edition 3. http://www.hydrolab.com/pdf/S5_Manual.pdf

Hach Company. 2006b. Instruction Sheet: Hach LDO™ Sensor. February 2006 Edition 4.

Mathieu, N. 2007. Standard Operating Procedure for Measuring Dissolved Oxygen in Surface Water, Version 1.1. Washington Department of Ecology, Environmental assessment Program, Olympia, WA.
http://www.ecy.wa.gov/programs/eap/qa/docs/ECY_EAP_SOP_035MeasuringDO_v1_1.pdf

Swanson, T. 2007. Standard Operating Procedures for Hydrolab® DataSonde® and MiniSonde® Multiprobes, Version 1.0. Washington Department of Ecology, Environmental assessment Program, Olympia, WA.
http://www.ecy.wa.gov/programs/eap/qa/docs/ECY_EAP_SOP_033Hydrolab.pdf

Appendix D

Water Sampling in Wadeable Streams

Purpose and Scope

This method explains how to collect water samples at wadeable streams for the Status and Trends Program. Grab-water samples are collected for these 5 parameters:

1. Total Phosphorus (by colorimetric analysis)
2. Total Nitrogen (by persulfate method)
3. Chloride
4. Turbidity
5. Total Suspended Solids

Definitions

Definitions of acronyms and other terms are found in Table D-1.

Table D-1. Definitions.

Term or Accronym	Definition
CL	chloride
DCE	Data Collection Event. Data are indexed using this code which includes the SITE_ID, the date, and the time that the event began. It uses this format: **WAM06600-NNNNNN-dce-20YY-MMDD-HHMM** **NNNNNN** = the number portion of the SITE_ID. **YY** = the last two numeric digits of the year that the event occurred. **MM** = the two numeric digits for the month that the event occurred. **DD** = the two numeric digits for the day within the month that the event occurred. **HHMM** = the military time when the event began.
Index Station	The point location mapped by the site coordinates. It is sometimes called "X". This is normally located at the mid-elevation of the stream site.
Master Sample	The list of 387,237 probabilistic sites (statewide). These sites were

	selected with a randomized (GRTS) design from the February 2005 version of the Washington State Department of Natural Resources watercourses (1:24,000).
MEL	Manchester Environmental Laboratory
SITE_ID	A unique 15-digit site identification code provided by the Master Sample list. It begins with "WAM06600-"
Thalweg Transect	One of 101 equidistant transects across the length of a site. Labeling includes the name of the major transect. For example the thalweg transects between (and including) major transects A and B would be labeled as follows: A0, A1, A2, A3, A4, A5, A6, A7, A8, A9, B0 (i.e.., thalweg transect A0 is identical to major transect A)
TP	total phosphorus
TPN	total persulfate nitrogen
TSS	total suspended solids
TURB	turbidity

Personnel Responsibilities

This method is performed by 1 or more persons. This method is applied at every DCE, at the start of the sampling event. Staff performing this method must have been trained. Staff performing this method should refrain from the use of sun screen or insect repellent.

Equipment, Reagents, Supplies

- No. 2 pencil
- *Chemistry and Sampling Form*
- *Laboratory Analyses Required Form*
- Gloves - Non-powdered nitrile
- Garbage bag
- Cooler, Ice
- Sample Tags (with laboratory-assigned sample numbers)
- Jar#26 for TP (Figure D-1)
- Jar#19 for TPN (Figure D-2)
- Jar#22 for Cl (Figure D-3)
- Jar#22 for TURB (Figure D-3)
- Jar#23 for TSS (Figure D-4)

Figure D-1. The 60-mL jar for total phosphorus water samples: (Manchester Laboratory Index # 26).

Figure D-2. The 125-mL jar for total persulfate nitrogogen water samples:
(Manchester Laboratory Index # 19).

Figure D-3. The 500-mL jar. (Manchester Laboratory Index # 22).
There is one each for chloride and tubidity water samples:

Figure D-4. The 1000-mL jar for total susppended solids water samples: (Manchester Laboratory Index # 23).

Summary of Procedure

This method is based on Joy (2006). Collect water samples first, before other in-stream activities. Fill stream water into each of 5 polypropylene jars (Table D-2). Immediately chill the samples in the dark. Deliver them to the Manchester Environmental Laboratory (MEL) or to its courier within 24 hours of collection.

Table D-2. Handling requirements for water samples.

PARAMETER	JAR SIZE	HOLDING TIME BEFORE ANALYSIS[a]
TP[b]	60 mL	28 days
TPN[c]	125 mL	28 days
CL	500 mL	28 days
TURB	500 mL	48 hours
TSS	1000 mL	7 Days

a All water samples need to be chilled (0-6 ˚C).
b The jar for total phosphorus is pre-acidified with 0.25 mL 1:1 HCl
c The jar for total persulfate nitrogen is pre-acidified with 0.25 mL 1:1 H2SO4

Pre-sampling preparation

Sample Numbers, Jars and Tags

Prior to the field season, the Department of Ecology's Environmental Assessment Program (EAP) will help to prepare by performing two tasks.

1) EAP will obtain sample numbers from the Manchester Environmental Laboratory by submitting a *Pre-sampling Notification Form* (MEL, 2008).
2) EAP will order the sample jars and labels from the Manchester Environmental Laboratory by submitting the *Sample Container Request Form* (MEL, 2008).

Collecting Samples

Water samples are collected near the index station (near transect F0). Samples can be collected elsewhere within the site if necessary, but only if they can be collected from below transect K0 and above transect A0.

For each jar, remove the lid just before sampling. Be careful not to contaminate the cap, neck, or the inside of the bottle.

Chloride (CL), Turbidity (TURB) and Total Suspended Solids (TSS)

Stand in relatively deep, relatively non-turbulent water. Face upstream. Hold the container near its base, reach out in front of yourself as far a possible, and plunge it (mouth down) below the surface to about elbow depth. Make sure not to disturb sediments. Leave enough headspace so that the laboratory staff can mix the sample.

Total Phosphorus (TP) and Total Persulfate Nitrogen (TPN)

Stand in relatively deep, relatively non-turbulent water. Face upstream. Hold the container upright and place the lid over the mouth so that only a small area forms an opening (Figure D-5). Immerse the jar 15 cm (6 in) while holding the cap in position with your fingers as far away from the opening as possible. Carefully monitor the filling rate to avoid overfilling.

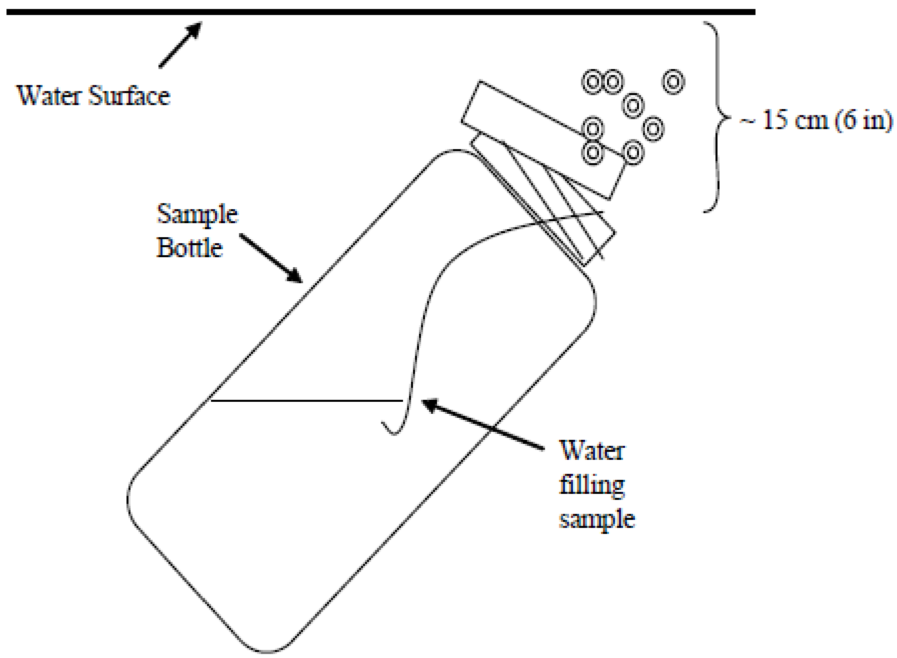
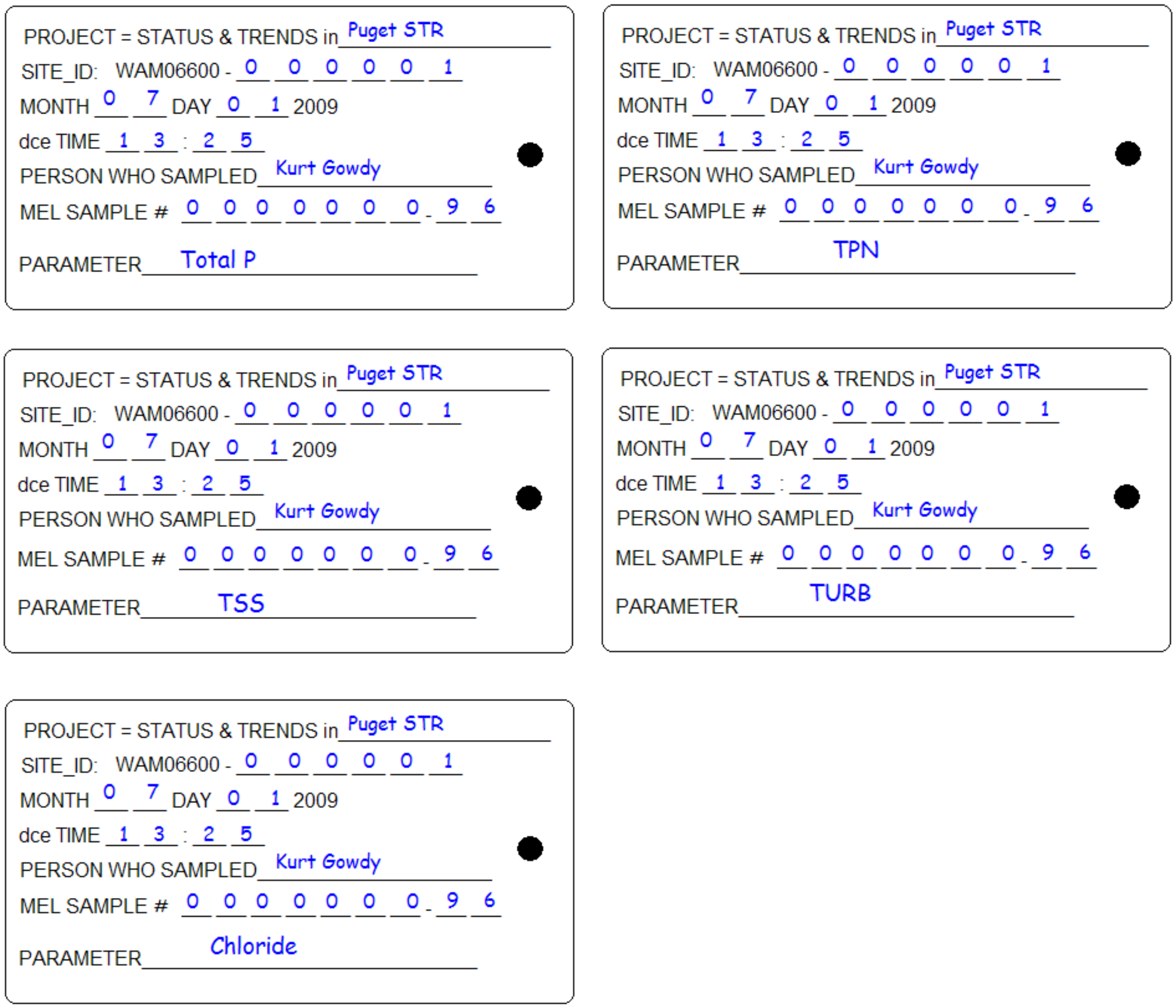


Figure D-5. Cap position during sample collection, when using jars that have been pre-filled with acid preservative (TPN and TP).

Field Processing

Labeling

For each jar, loop the string of the sample tag over the lid until it is secure. Use at least three loops for 250 mL jars and at least two loops for 500 mL jars or larger. Check the tag to ensure that the Master Sample SITE_ID number is recorded (this is the 6-digit number that follows “WAM06600-“ on the SITE_ID. Also record the data and time that appears in the DCE. Use waterproof ink or pencil. An example tag is provided in Figure D-6.



PROJECT = STATUS & TRENDS in Puget STR
SITE_ID: WAM06600 - 0 0 0 0 0 1
MONTH 0 7 DAY 0 1 2009
dce TIME 1 3 : 2 5
PERSON WHO SAMPLED Kurt Gowdy
MEL SAMPLE # 0 0 0 0 0 0 0 - 9 6
PARAMETER Total P

PROJECT = STATUS & TRENDS in Puget STR
SITE_ID: WAM06600 - 0 0 0 0 0 1
MONTH 0 7 DAY 0 1 2009
dce TIME 1 3 : 2 5
PERSON WHO SAMPLED Kurt Gowdy
MEL SAMPLE # 0 0 0 0 0 0 0 - 9 6
PARAMETER TPN

PROJECT = STATUS & TRENDS in Puget STR
SITE_ID: WAM06600 - 0 0 0 0 0 1
MONTH 0 7 DAY 0 1 2009
dce TIME 1 3 : 2 5
PERSON WHO SAMPLED Kurt Gowdy
MEL SAMPLE # 0 0 0 0 0 0 0 - 9 6
PARAMETER TSS

PROJECT = STATUS & TRENDS in Puget STR
SITE_ID: WAM06600 - 0 0 0 0 0 1
MONTH 0 7 DAY 0 1 2009
dce TIME 1 3 : 2 5
PERSON WHO SAMPLED Kurt Gowdy
MEL SAMPLE # 0 0 0 0 0 0 0 - 9 6
PARAMETER TURB

PROJECT = STATUS & TRENDS in Puget STR
SITE_ID: WAM06600 - 0 0 0 0 0 1
MONTH 0 7 DAY 0 1 2009
dce TIME 1 3 : 2 5
PERSON WHO SAMPLED Kurt Gowdy
MEL SAMPLE # 0 0 0 0 0 0 0 - 9 6
PARAMETER Chloride

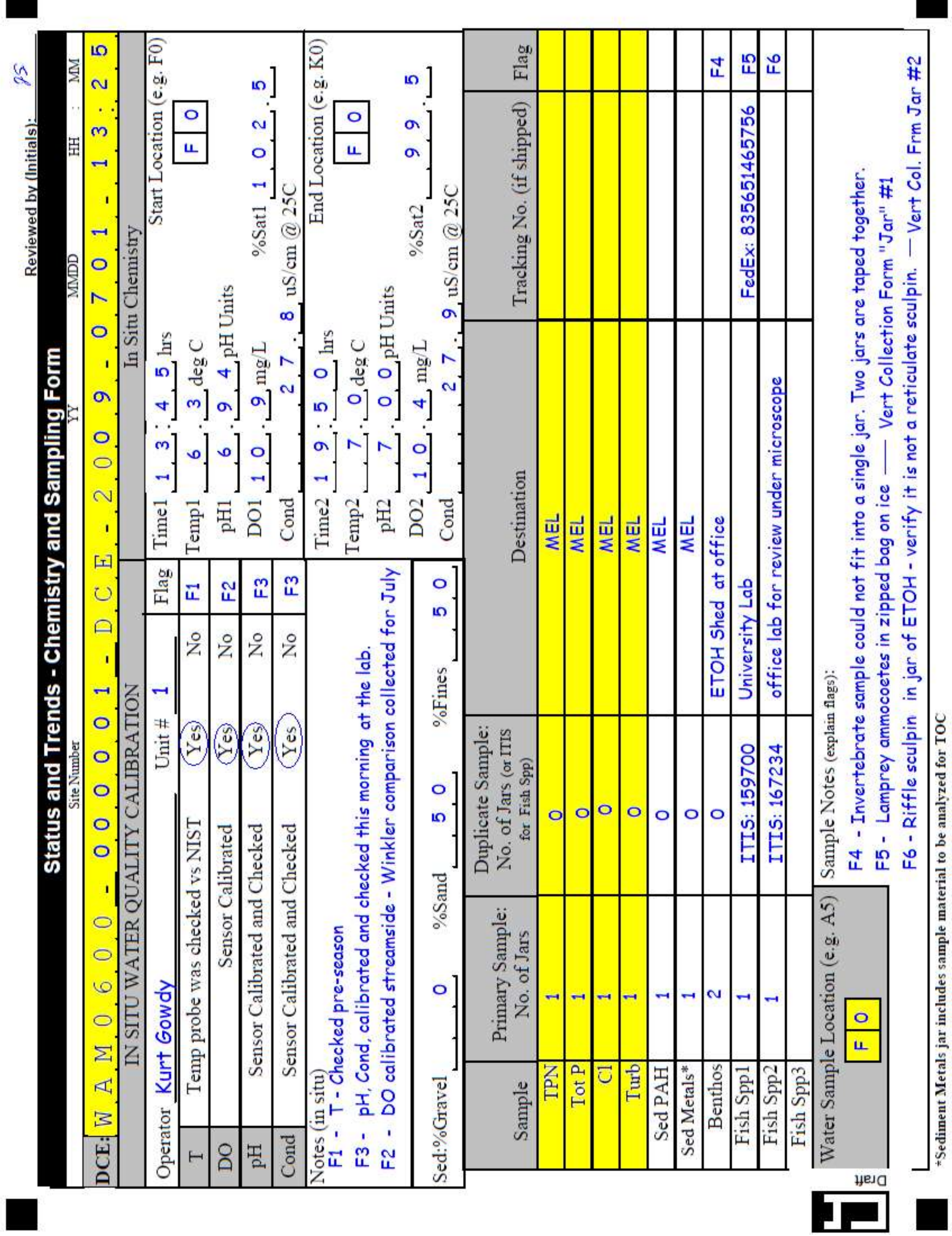
Figure D-6. Example tags for water chemistry jars.

Storage

If you are sampling close to your vehicle, immediately place samples in a cooler of ice. If you are sampling remotely, maintain samples in a sealed black garbage bag that is immersed in the stream and in the shade until you are ready to leave the site (Peck and others 2006). Place samples into a cooler of ice as soon as possible.

Chemistry and Sampling Form

Complete the relevant portions of the *Chemistry and Sampling Form* (Figure D-7) including how many jars were collected for each parameter. Also make sure that the header information is complete and that the sample location is specified according to the code for the closest Thalweg Transect. If the samples are delivered through a commercial courier, be sure to record the courier's tracking number for the shipment.



Reviewed by (Initials): JS

Status and Trends - Chemistry and Sampling Form

Site Number			YY	MMDD	HH : MM
DCE: W A M 0 6 0 0	0 0 0 0 0 1	D C E	2 0 0 9	0 7 0 1	1 3 : 2 5

IN SITU WATER QUALITY CALIBRATION

Operator Kurt Gowdy Unit # 1

				Flag
T	Temp probe was checked vs NIST	Yes	No	F1
DO	Sensor Calibrated	Yes	No	F2
pH	Sensor Calibrated and Checked	Yes	No	F3
Cond	Sensor Calibrated and Checked	Yes	No	F3

Notes (in situ)
F1 - T - Checked pre-season
F3 - pH, Cond, calibrated and checked this morning at the lab.
F2 - DO calibrated streamside - Winkler comparison collected for July

Sed:%Gravel 0 %Sand 5 0 %Fines 5 0

In Situ Chemistry

Time1 1 3 : 4 5 hrs Start Location (e.g. F0) F 0
Temp1 6 . 3 deg C
pH1 6 . 9 4 pH Units
DO1 1 0 . 9 mg/L %Sat1 1 0 2 . 5
Cond 2 7 . 8 uS/cm @ 25C

Time2 1 9 : 5 0 hrs End Location (e.g. K0) F 0
Temp2 7 . 0 deg C
pH2 7 . 0 0 pH Units
DO2 1 0 . 4 mg/L %Sat2 9 9 . 5
Cond 2 7 . 9 uS/cm @ 25C

Sample	Primary Sample: No. of Jars	Duplicate Sample: No. of Jars (or ITIS for Fish Spp)	Destination	Tracking No. (if shipped)	Flag
TPN	1	0	MEL		
Tot P	1	0	MEL		
Cl	1	0	MEL		
Turb	1	0	MEL		
Sed PAH	1	0	MEL		
Sed Metals*	1	0	MEL		
Benthos	2	0	ETOH Shed at office		F4
Fish Spp1	1	ITIS: 159700	University Lab	FedEx: 835651465756	F5
Fish Spp2	1	ITIS: 167234	office lab for review under microscope		F6
Fish Spp3					

Water Sample Location (e.g. A5) F 0

Sample Notes (explain flags):
F4 - Invertebrate sample could not fit into a single jar. Two jars are taped together.
F5 - Lamprey ammocoetes in zipped bag on ice —— Vert Collection Form "Jar" #1
F6 - Riffle sculpin in jar of ETOH - verify it is not a reticulate sculpin. — Vert Col. Frm Jar #2

*Sediment Metals jar includes sample material to be analyzed for TOC
Note: Use standard Manchester Environmental Lab forms for tracking water and sediment samples.

Draft

Figure D-7. The Chemistry and Sampling Form, with example data for this method highlighted in yellow.

References

Joy, J. 2006. Standard Operating Procedure for Manually Obtaining Surface Water Samples SOP EAP015. Washington State Department of Ecology, Environmental Assessment Program, Olympia.
http://www.ecy.wa.gov/programs/eap/qa/docs/ECY_EAP_SOP_015ManuallyObtainingSurfaceWaterSamples.pdf

Manchester Environmental Laboratory. 2008. Manchester Environmental Laboratory Lab Users' Manual, Ninth Edition. Manchester Environmental Laboratory, Washington State Department of Ecology, Manchester.
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Peck, D.V., Herlihy, A.T., Hill, B.H., Hughes, R.M., Kaufmann, P.R., Klemm, D.J., Lazorchak, J.M., McCormick, F.H., Peterson, S.A., Ringold, P.L., Magee, T., and Cappaert, M.R. 2006. Environmental Monitoring and Assessment Program-Surface Waters, Western Pilot Study, Field Operations Manual for Wadeable Streams. EPA/620/R-06/003. U.S. Environmental Protection Agency, Washington, D.C.
http://www.epa.gov/wed/pages/publications/authored/EPA620R-06003EMAPSWFieldOperationsManualPeck.pdf

Appendix E

Estimating Discharge in Wadeable Streams

Purpose and Scope

This method describes how to collect field data necessary for estimating instantaneous discharge (in cubic feet per second) during each data collection event for Washington's Status and Trends Program. Data will be used to categorize streams according characteristics of the stream at the time of sampling (approximate base-flow conditions). It applies to waded streams.

Definitions

Definitions of acronyms and other terms are found in Table E-1.

Table E-1. Definitions.

Term or Accronym	**Definition**
Index station	This is sometimes called "X". It is the location of the coordinates provided by the Master Sample. For waded streams this is normally (not always) in the middle of the site, at Thalweg Transect F0.
Left	The side of the stream that is to the left of a person facing downstream.
Right	The side of the stream that is to the right of a person facing upstream.
Segment	The lengthwise portion of the stream through which a floating object's path is timed.
Stations	For discharge measurements, these are the multiple (up to 20) data collection points along a transect that crosses the stream channel from left wetted margin to the right wetted margin. Margins are included.
Thalweg Transect	The Thalweg Transect is used to describe the longitudinal position within the site. The stream site is divided longitudinally using 101 equidistant Thalweg Transects that cut across the deepest part of the channel. These are labeled as follows: A0, A1, A3, A4, A5, A6, A7, A8, A9, B0,...K0.

Personnel Responsibilities

One person performs this activity. Staff performing this method must have been trained.

Equipment, Reagents, Supplies

- Soft-lead pencil
- *Chemistry and Sampling Form*
- Distance measuring device (50-m tape or measuring rod)
- Flow Meter
- Wading rod (top setting)
- Orange or other neutrally buoyant object.
- 5-gallon bucket
- Stop watch
- Field notebook
- Calculator

Discharge is normally measured near the index station ("X") where there is uniform (non-turbulent) flow. It can be done at any time during the data collection event, except prior to sampling for water, sediment, or invertebrates. This method references Sullivan (2007) and Kaufmann (2006). For operation of the flow meter, refer to the manufacturer's manual (e.g. Marsh-McBirney, 1990).

For calculation of discharge (from meter data), refer to USBR (2001). The QWIN program created by Larson (2003) applies the USBR Midsection Method. Example data and on-line access to QWIN are provided by PSNS&IMF (2006).

Conditions may not always allow for use of flow meters. In these cases, discharge can be estimated through alternate methods. Examples of alternate methods are:

- Velocity of floats (e.g. oranges)
- Time to fill a bucket of known volume (e.g. discharge off of a hanging culvert)
- Retrieval of data from co-located gages or models

Velocity-Area Method

Use the Discharge Worksheet (Figure E-1), located on the back of the Chemistry and Sampling Form. Discharge can be calculated by converting widths to units of feet (nearest tenth) and applying the QWIN program (Larson, 2005) as provided by PSNS&IMF (2006).

Flow Location - Thalweg Station (e.g. A5) : F 0 Flow Meter (Model / Unit #) Marsh McBirney Flo-Mate 2000 / 2

Discharge Worksheet

Flow Meter Zeroed Out? Y N Wetted Width: 1026 cm

Cell	Tape Distance Left to Right (cm)	Wetted Depth (ft.x)	Velocity (ft.xx/s)	Notes
01	10	0	0	Left edge of water
02	64	0.5	0.65	
03	118	1.0	0.49	
04	172	1.0	0.76	
05	226	1.3	2.29	
06	280	1.2	0.51	
07	334	1.8	1.66	
08	388	2.0	3.77	
09	442	2.1	3.61	
10	496	2.3	3.26	
11	550	2.2	3.21	
12	604	2.3	2.37	
13	658	1.7	1.74	
14	712	1.5	1.10	
15	766	1.0	0.95	
16	820	0.7	0.66	
17	874	0.5	0.54	
18	928	0.3	0.32	
19	982	0	0.15	
20	1036	0	0	Right wetted margin

Describe Alternate Method: N/A

Discharge: 88.2 cfs

Draft

Figure E-1. The Discharge Worksheet with example field data in blue.

Establish the cross-section

The velocity-area method is used at a transect location within the site that has the most of these conditions (based on Rantz and others, 1982).

- The stream is straight,
- Depths are mostly greater than 0.5 ft (15 cm),
- Velocities are mostly greater than 50 ft/s (0.15 ms/s).
- Local habitat is not a pool,
- The channel is "U-shaped", and
- The streambed is uniform and free of objects that cause turbulence.

Preference should be given to locations that are close to "X". Record the name of the nearest *Thalweg Transect*.

Pull a measuring tape taught, perpendicular to the stream, and parallel to the stream surface (a measuring rod can be used for narrow streams). Record the tape value (cm) at the left wetted margin and at the right wetted margin. Subtract the left value from right value to determine the transect's wetted width. Record wetted width (cm) on the worksheet (Figure E-1).

Measure distance, depth, and velocity

Define about 15-20 equally-spaced stations across the stream (possibly fewer for very small streams). To determine spacing between stations, divide the width by 20 and round up to a convenient number. Stations should not be closer than 10 cm to each other, even if this results in less than 15 stations. The first station is located at the left wetted margin, and the last station is located at the right wetted margin.

Use a calibrated flow meter equipped with a top-setting wading rod that has depth increments in tenths of feet. At each station, record the tape distance (cm) from left to right. Record the water depth (nearest 0.1 ft). Place the sensor 60% of the distance down from the surface (Figure E-2). Measure and record water velocity (nearest 0.01 f/s).

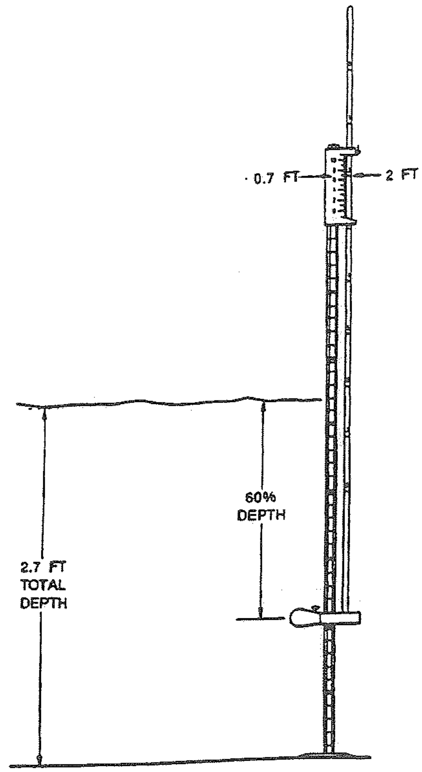

Figure E-2. Setting the wading rod at 60% depth when at a station that is 2.7 meters deep. Modified from Marsh-McBirney (1990).

Alternate Methods

Conditions may not always allow for use of flow meters. In these cases, discharge can be estimated through alternate methods such as those listed below. At the bottom of the *Discharge Worksheet* (Figure E-1), record which alternate method was used. If an alternate method other than the timed float was used, record the estimated discharge value (cfs).

Examples of alternate methods are:

- Velocity of timed floats (e.g. oranges, plastic golf balls, sticks)
- Time to fill a bucket of known volume (e.g. discharge off of a hanging culvert)
- Obtaining collocated gage data or model data.

Timed Float

In the absence of a current meter, you can time the transport of a neutrally-buoyant object to estimate velocity. This method is similar to the Velocity-Area method because discharge is calculated as the product of water velocity and the stream cross-sectional area. Requirements are:

- The object must float, but very low in the water.
- The object must be small enough to *not* drag bottom.
- The segment must be somewhat strait, uniform and non-turbulent.
- The segment must be long enough that it takes 10 to 30 seconds for the float to pass.

Velocity

Compute water column velocity in a field notebook. Determine the average time (seconds) for the float to travel the segment. Repeat twice more, each time releasing at a different position across the width of the stream. Compute an average for the three times. Measure the length of the segment (ft). Divide the segment length by the average time of travel (s) to estimate surface velocity (ft/s). Multiply this surface velocity by 0.85 to estimate water column velocity.

Cross-sectional area

Compute cross-sectional area (ft^2) in a field notebook. This can be done by summing the area for at least two trapezoids to approximate the cross section of the stream (Figure E-2). These should be centered on the thalweg.

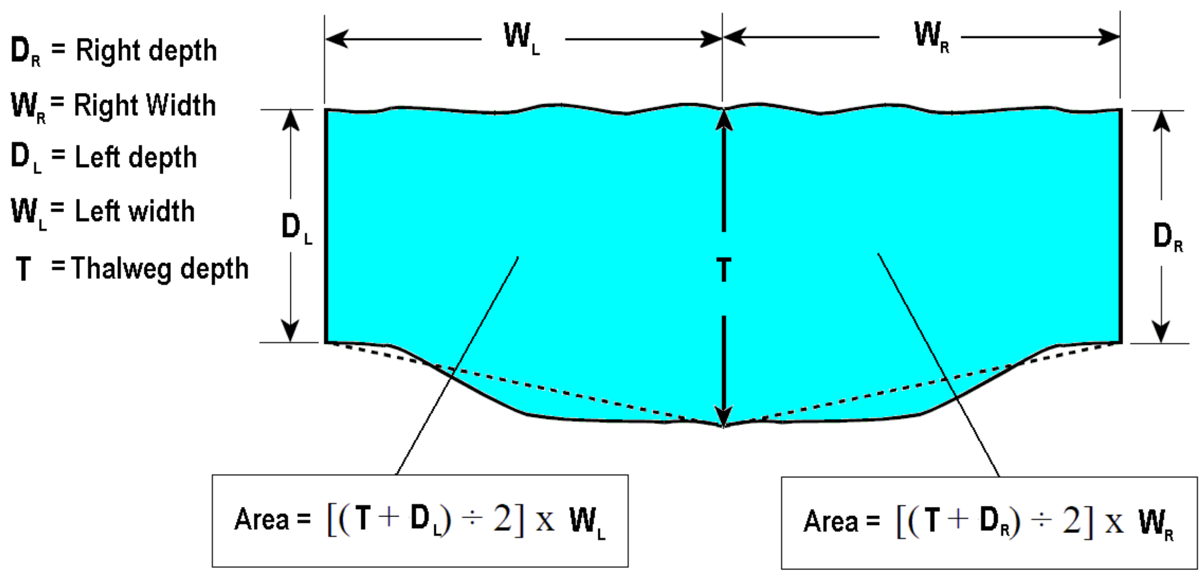

Figure E-2. The cross-sectional area of a stream segment as estimated by calculating the area of component trapezoids, centered on the thalweg.

Measure area for one or more cross-sections and average them. Only one cross-section is adequate if the channel is relatively uniform through the segment. Otherwise measure at these cross-sections:

- near the top of the segment
- near the middle of the segment
- near the bottom of the segment

If there is little change in channel width or depth, obtain measurements from a single “typical” cross-section within the segment.

Discharge

Convert cross-sectional area calculations to square feet (1 m^2 = 10.76391 ft^2). Then multiply water column velocity (ft/s) times the cross-sectional area (ft^2) to determine stream discharge for the site. Record this discharge (cfs) on the bottom of the discharge worksheet (Figure E-1). Also record “timed float” next to “Describe alternate method”.

Timed Bucket-Filling

Place a bucket or other container with known volume below the discharge. Time how long it takes to fill the container. Repeat at least three times. Calculate discharge as the volume of the container divided by the average time to fill it. Use Table E-1 to translate from gallons or milliliters to cubic feet. Record discharge (cfs) at the bottom of the Discharge Worksheet (Figure E-1). Also record that the alternate method was by use of a timed bucket-filling.

Table E-1. Conversions for gallons or milliliters to cubic feet.

Gallons	Milliliters	Cubic Feet
0.1321	500	0.0176573
0.2642	1,000	0.0353147
1	3,785	0.1336806
5	18,927	0.6684028
7.480519	28,317	1

Existing data

Record discharge (cfs) at the bottom of the Discharge Worksheet (Figure E-1) and note the data source, next to “Describe alternate method”.

References

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Appendix F

Sediment Chemistry Sampling

Purpose and Scope

This method explains how to collect a site-composite sediment sample in the Status and Trends Program. Stream sites are sampled within day-long data collection events (DCEs). Each composite sample will be composed of scoops taken from 3 separately-located shallow-water stations in the site. To detect the presence of select contaminants at the site, the sample will be analyzed for metals (copper, lead, zinc, arsenic) and a standard list of polynuclear aromatic hydrocarbon (PAH) compounds. To help interpret the results, the sample will also be analyzed for total organic carbonand grain size composition.

Definitions

Definitions of acronyms and other terms are found in Table F-1.

Table F-1. Definitions.

Term or Accronym	Definition
DCE	Data Collection Event
GC/MS	Gas Chromatography Mass Spectrometry
ICP	Inductively Coupled Plasma
Index Station	The point location mapped by the site coordinates. It is sometimes called “X”. This is normally located at the mid-elevation of the stream site.
MEL	Manchester Environmental Laboratory
MSDS	Material Safety Data Sheet. Written, printed, or electronic information (on paper, microfiche, or on-screen) that informs manufacturers, distributors, employers or employees about a hazardous chemical, its hazards, and protective measures as required by material safety data sheet and label preparation, Chapter 296-839 WAC.
PAH	Polynuclear Aromatic Hydrocarbon. For Status and Trends there are 24 standard analytes: Naphthalene 2-Methylnaphthalene 1-Methylnaphthalene 2-Chloronaphthalene Acenaphthylene Acenaphthene

	Dibenzofuran Fluorene Phenanthrene Anthracene Carbazole Phenanthrene, 3,6-dimethyl- Fluoranthene Pyrene Retene Benzo(k)fluoranthene Benzo(a)pyrene Perylene Indeno(1,2,3-cd)pyrene Dibenzo(a,h)anthracene Benzo(ghi)perylene Chrysene Benzo(b)fluoranthene Benzo(a)anthracene
TOC	Total Organic Carbon

Personnel Responsibilities

This sampling method is performed by 1 person in the field. Pre-sampling pre-cleaning activities should be performed by staff familiar with MSDS and safety procedures. This method is applied at every DCE. Staff performing this method must have been trained. Staff performing this method should refrain from the use of sun screen or insect repellent.

Equipment, Reagents, Supplies

- Stainless steel bowl with sealed stainless steel cover (about 6)
- Stainless steel spoon (about 6)
- Turkey baster (3)
- No. 2 pencil
- *Chemistry and Sampling Form*
- *Laboratory Analyses Required Form*
- Gloves - Non-powdered nitrile
- Cooler, Ice
- Garbage Bag
- Sample Tags (with laboratory-assigned sample numbers)
- Jars (provided by the laboratory)
- Aluminum foil
- Wash bottle (labeled) with Liquinox or Alconox
- Wash bottle (labeled) with acetone (pesticide grade)
- Wash bottle (labeled) with 10% nitric acid
- MSDS
- Personal protective gear as specified by the MSDS
- Fume hood

Summary of Procedure

These procedures are derived from methods described in Johnson (1997), Blakely (2008a), and Manchester Environmental Laboratory (2008). Surface sediment samples are collected for laboratory analyses (Table F-2). The crew will analyze grain sizes of the sample while in the field. Samples are chilled immediately and delivered to the laboratory or a courier within 14 days of collection, but normally within 24 hours.

Table F-2. Laboratory methods for sediment chemistry samples.

Analysis	Analytical Method	Reporting Limits
TOC	PSEP (1986, with 1997 update)[a] MEL (2008) page 120	0.1%
As	ICP Method 200.7 (EPA 1983) [b] , MEL (2008) page 134	0.1 mg/Kg, dry
Cu	ICP Method 200.7 (EPA 1983) [b] MEL (2008) page 134	0.1 mg/Kg, dry
Pb	ICP Method 200.7 (EPA 1983) [b] MEL (2008) page 134	0.1 mg/Kg, dry
Zn	ICP Method 200.7 (EPA 1983) [b] MEL (2008) page 134	5 mg/Kg, dry
PAHs	GC/MS Method 8270 (EPA 1996) [b] MEL (2008) page 164	40 µg/Kg, dry

a Find method quality objectives in Blakely (2008b), Table 8.
b Find method quality objectives in Meredith and Furl (2008), Table 2.

Pre-sampling preparation

Sample Numbers, Jars and Tags

Prior to the field season, the Department of Ecology's Environmental Assessment Program (EAP) will help to prepare by performing two tasks.

3) EAP will obtain sample numbers from the Manchester Environmental Laboratory by submitting a *Pre-sampling Notification Form* (MEL, 2008).
4) EAP will order the sample jars and labels from the Manchester Environmental Laboratory by submitting the *Sample Container Request Form* (MEL, 2008).

Pre-cleaning

On a weekly basis, field crews will pre-clean enough sampling tools to last a week (including spares).

These are the pre-washing steps for each bowl, spoon and turkey baster:

1) Wash in Liquinox detergent, then
2) Rinse (three times) with tap water, then
3) Wash with 10% nitric acid, then
4) Rinse with deionized water, then
5) **In fume hood**, rinse with acetone, then
6) **In fume hood,** rinse with hexane, then
7) **In fume hood,** air dry, then

8) Wrap with aluminum foil (shiny side of foil facing out).
9) Properly dispose of hazardous wastes.

Sampling

Use pre-cleaned equipment that has been wrapped in foil.

Collect the sample by compositing from each of three suitable locations near the point of arrival. A suitable location will have these characteristics:

- Surface sediment is dominated by particles < 2 mm diameter,
- Water depth above the sediment is < than 30 cm,
- The station is always under water throughout the day.
- Anywhere within 10 bankfull widths (upstream or downstream) of the index station.
- Upstream from where staff have entered the stream channel.

Using a stainless steel spoon, sample the top 2 cm of sediment and place it into a stainless steel mixing bowl. Let the sample settle, then use the turkey baster to remove overlying water. Homogenize the sample by stirring with the spoon until a uniform color and texture is achieved.

PAH Sample

Transfer sediment with the spoon into an 8-oz glass, wide-mouth jar (described as #6 by MEL, 2008). Screw the lid closed, label it, and place it into a cooler of ice. Record sample information on the *Chemistry and Sampling Form* (Figure F-1). Use the appropriate column depending upon whether documenting the primary sample or a duplicate for the date. For each sample:

- Record "MEL" for the "Destination"
- Record "1" for "No. Jars".

Metals and TOC Sample

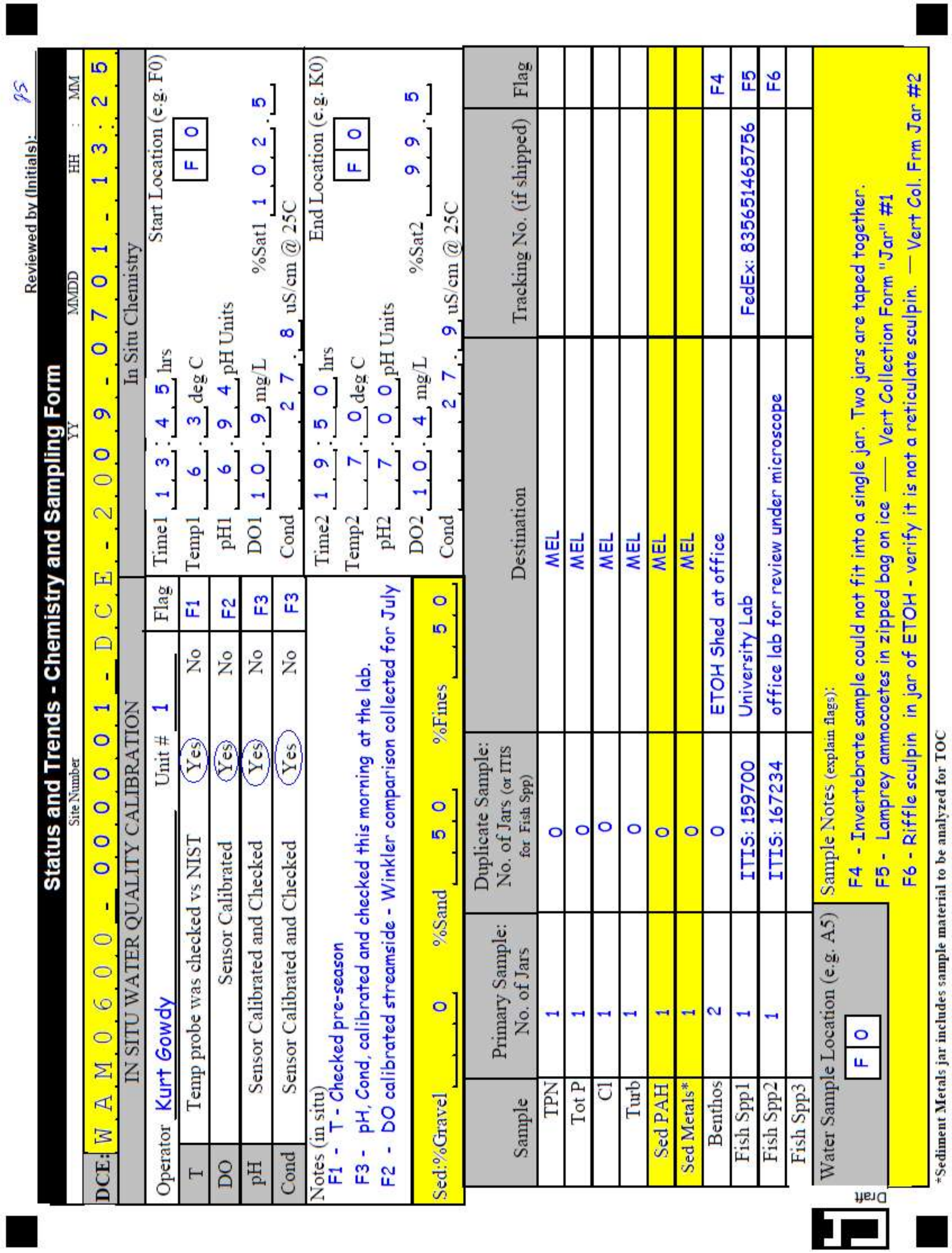
Transfer sediment with the spoon into an 8-oz glass, wide-mouth jar (described as #6 by MEL, 2008). Screw the lid closed, label it, and place it into a cooler of ice. Record sample information on the *Chemistry and Sampling Form* (Figure F-1). Use the appropriate column depending upon whether documenting the primary sample or a duplicate for the date. For each sample:

- Record "MEL" for the "Destination"
- Record "1" for "No. Jars".

Grain Size Analysis

Visually estimate the composition of the sediment in the composite sample. Record percent gravel, percent sand, and percent fines on the *Chemistry and Sampling Form* (Figure F-1). Gravel should never be a dominant component of the sample. Sand is gritty to the touch whereas fines are not. You can check the feel of *residue in the bowl* for presence of sand or fines *only* after sample jars have been filled and placed on ice.

- Gravel (> 2mm)
- Sand (2-16 mm)
- Fines (silt/clay/muck)



Reviewed by (Initials): JS

Status and Trends - Chemistry and Sampling Form

	Site Number	YY	MMDD	HH : MM
DCE:	W A M 0 6 0 0 - 0 0 0 0 0 1 - D C E -	2 0 0 9 -	0 7 0 1 -	1 3 : 2 5

IN SITU WATER QUALITY CALIBRATION

Operator Kurt Gowdy		Unit # 1		Flag
T	Temp probe was checked vs NIST	Yes	No	F1
DO	Sensor Calibrated	Yes	No	F2
pH	Sensor Calibrated and Checked	Yes	No	F3
Cond	Sensor Calibrated and Checked	Yes	No	F3

Notes (in situ)
F1 - T - Checked pre-season
F3 - pH, Cond, calibrated and checked this morning at the lab.
F2 - DO calibrated streamside - Winkler comparison collected for July

Sed:%Gravel 0 %Sand 5 0 %Fines 5 0

In Situ Chemistry

Time1 1 3 : 4 5 hrs — Start Location (e.g. F0) F 0
Temp1 6 . 3 deg C
pH1 6 . 9 4 pH Units
DO1 1 0 . 9 mg/L — %Sat1 1 0 2 . 5
Cond 2 7 . 8 uS/cm @ 25C

Time2 1 9 : 5 0 hrs — End Location (e.g. K0) F 0
Temp2 7 . 0 deg C
pH2 7 . 0 0 pH Units
DO2 1 0 . 4 mg/L — %Sat2 9 9 . 5
Cond 2 7 . 9 uS/cm @ 25C

Sample	Primary Sample: No. of Jars	Duplicate Sample: No. of Jars (or ITIS for Fish Spp)	Destination	Tracking No. (if shipped)	Flag
TPN	1	0	MEL		
Tot P	1	0	MEL		
Cl	1	0	MEL		
Turb	1	0	MEL		
Sed PAH	1	0	MEL		
Sed Metals*	1	0	MEL		
Benthos	2	0	ETOH Shed at office		F4
Fish Spp1	1	ITIS: 159700	University Lab	FedEx: 835651465756	F5
Fish Spp2	1	ITIS: 167234	office lab for review under microscope		F6
Fish Spp3					

Water Sample Location (e.g. A5) F 0

Sample Notes (explain flags):
F4 - Invertebrate sample could not fit into a single jar. Two jars are taped together.
F5 - Lamprey ammocoetes in zipped bag on ice —— Vert Collection Form "Jar" #1
F6 - Riffle sculpin in jar of ETOH - verify it is not a reticulate sculpin. — Vert Col. Frm Jar #2

Draft

*Sediment Metals jar includes sample material to be analyzed for TOC
Note: Use standard Manchester Environmental Lab forms for tracking water and sediment samples.

Figure F-1. The Chemistry and Sampling Form, with fields for sediment chemistry data highlighted.

Field Processing

Storage

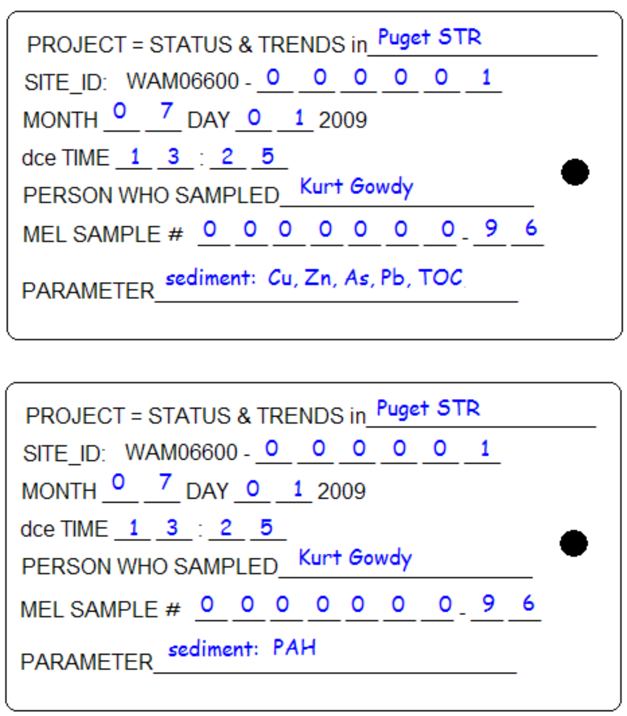
If you are sampling close to your vehicle, immediately place samples in a cooler of ice. If you are sampling remotely, maintain samples in a sealed black garbage bag that is immersed in the stream and in the shade until you are ready to leave the site. Place samples into a cooler of ice as soon as possible.

Labeling

For each jar, loop the string of the sample tag over the lid until it is secure. Use at least three loops for 250 mL jars and at least two loops for 500 mL jars or larger. Check the tag to ensure that the Master Sample SITE_ID number is recorded (this is the 6-digit number that follows "WAM06600-" on the SITE_ID. Also record the data and time that appears in the DCE. Use waterproof ink or pencil. An example set of tags is provided in Figure F-2.

Sample Delivery

Sample Crews will complete a *Laboratory Analyses required Form* (MEL, 2008) and submit it with samples at a drop-off location designated by the Manchester Environmental Laboratory. The Laboratory Analyses Required (LAR) form will serve as a chain-of-custody form. Sediment chemistry samples have a 14-day field holding time (while at 0-6 ˚C). Normally though, they can be submitted with water samples which need to be submitted within 24 hours of collection.



PROJECT = STATUS & TRENDS in Puget STR
SITE_ID: WAM06600 - 0 0 0 0 0 1
MONTH 0 7 DAY 0 1 2009
dce TIME 1 3 : 2 5
PERSON WHO SAMPLED Kurt Gowdy
MEL SAMPLE # 0 0 0 0 0 0 0 - 9 6
PARAMETER sediment: Cu, Zn, As, Pb, TOC

PROJECT = STATUS & TRENDS in Puget STR
SITE_ID: WAM06600 - 0 0 0 0 0 1
MONTH 0 7 DAY 0 1 2009
dce TIME 1 3 : 2 5
PERSON WHO SAMPLED Kurt Gowdy
MEL SAMPLE # 0 0 0 0 0 0 0 - 9 6
PARAMETER sediment: PAH

Figure F-2. Example tags for sediment chemistry sample jars.

References

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Appendix G

Sampling Benthos in Wadeable Streams

Purpose and Scope

This method describes how to collect benthic macroinvertebrate samples for conducting community level assessments in Washington's Status and Trends Program. Data will be used to describe biological integrity and ecological quality (or taxonomic loss). It applies to waded streams. This method requires measurement of the associated physical and chemical environmental variables described in other methods within this protocol.

Definitions

Definitions of acronyms and other terms are found in Table G-2.

Table G-2. Definitions.

Term or Accronym	**Definition**
Biological Integrity	"The ability to support and maintain a balanced, integrated, and adaptive community of organisms having a species composition, diversity and functional organization comparable to those of natural habitats within a region" (Karr and Dudley, 1981).
Ecological Quality	For this method, ecological quality refers to the ratio of observed to expected natural taxa (Wright et al 2000). This is the observed number of native taxa collected relative to the number of taxa predicted based on a model of reference condition.
Kick	One of the 8 components to a site's composite benthos sample. One kick is collected at each of 8 transects within the site. The area of a kick is 1 ft^2 (0.743 m^2) of stream bottom.

Personnel Responsibilities

One person or more performs this activity. Staff performing this method must have been trained.

Equipment, Reagents, Supplies

- Wide-mouth polyethylene jar (128 oz or 3.8 L)
- D-Frame kick net with these characteristics
  - Frame mouth that is 1 ft (30.5 cm) wide by 1 ft tall.
  - 500-µm mesh net
- 95% Ethanol (add 3 parts by volume for each part sample)
- Label (waterproof) for jar exterior
- Label (waterproof) for jar interior
- Soft-lead pencil
- Clear tape
- Electrical tape
- Pocket knife
- Wading gear

Summary of Procedure

Invertebrate sampling is one of the first methods to be performed on-site, after site verification and layout. It starts concurrently with water sampling, with initial components of the benthos sample collected downstream of the water sample. One kick sample is collected at each of 8 transects and added to the composite sample for the site. This method is taken from Hayslip (2007) with some details provided by Peck et al (2006).

Choose transects

Randomly choose 8 transect stations out of these 11:

- A0
- B0
- C0
- D0
- E0
- F0
- G0
- H0
- I0
- J0
- K0

Identify kick stations

Start at the lowest transect and work upstream. At each transect, visually estimate the distance from left to right where the stream bottom will be sampled (Table G-1). Half the stations are in mid-channel. Half are in margins. If the water is too deep to sample at any station, collect the sample from the nearest feasible location. The kick net normally allows sampling up to about 50 cm depths.

Table G-1. Components of the macroinvertebrate composite sample.

Kick Station	Distance across wetted channel (left to right)
1st	25%
2nd	50%
3rd	75%
4th	50%
5th	25%
6th	50%
7th	75%
8th	50%

Collect each kick

A different procedure is needed depending upon whether the station sits within flowing water or slack water. Flowing water is where the stream current can sweep organisms into the net. Slack water is where water is so slow that active net movement is required to collect organisms.

Flowing water stations

Once the kick station is determined, place the net opening into the face of flow. Position the net quickly and securely on the stream bottom to eliminate gaps under the frame. Collect benthic macroinvertebrates from a $1ft^2$ ($0.9\ m^2$) quadrat located directly in front of the frame mouth.

Work from the upstream edge of the quadrat backward and carefully pick up and rub stones directly in front of the net to remove attached animals. Quickly inspect each stone to make sure you have dislodged everything and then set it aside. If a rock is lodged in the stream bottom, rub it a few times concentrating on any cracks or indentations.

After removing all large stones, keeping the sampler securely in position, starting at the upstream end of the quadrat, kick the top 4 to 5 cm of the remaining finer substrate within the quadrat for 30 seconds.

Pull the net up out of the water. Immerse the net in the stream several times or splash the outside of the net with stream water to remove fine sediments and to concentrate organisms at the end of the net. After completing the sample, hold the net vertically and rinse material to the bottom of the net.

After taking a sample, examine the contents of the net. Pick out coarse rocks and sticks. Closely examine them for clinging organisms; pick these animals off of the debris and place them into the sample jar. Discard the debris and empty the net's remaining contents into the sample jar.

Add enough ethanol to the sample jar so that the resulting solution consists of 1/3 sample and 2/3 ethanol (by volume).

Slack water stations

Visually define a rectangular quadrat with an area of 1 ft^2 (0.09 m^2). Inspect the stream bottom within the quadrat for any heavy organisms, such as mussels and snails. Remove these organisms by hand and place them into the sample jar. Pick up any loose rocks or other larger substrate particles within the quadrat and hold them in front of the net. Use your hands to rub any clinging organisms off of rocks or other pieces of larger substrate (especially those covered with algae or other debris) into the net. After scrubbing, place the larger substrate particles outside of the quadrat.

Vigorously kick the remaining finer substrate within the quadrat with your feet while dragging the net repeatedly through the disturbed area just above the bottom. Keep moving the net all the time so that the organisms trapped in the net will not escape. Continue kicking the substrate and moving the net for 30 seconds.

After 30 seconds, remove the net from the water with a quick upstream motion to wash the organisms to the bottom of the net.

After taking a sample, examine the contents of the net. Pick out coarse rocks and sticks. Closely examine them for clinging organisms; pick these animals off of the debris and place them into the sample jar. Discard the debris and empty the net's remaining contents into the sample jar.

Add enough ethanol to the sample jar so that the resulting solution consists of 1/3 sample and 2/3 ethanol (by volume).

Special circumstances

For samples located within dense beds of long, filamentous aquatic vegetation, kicking may not be effective. Use a knife to sample only the vegetation that lies ***within*** the quadrat. Don't include parts of the strands that extend beyond the quadrat.

Label and Seal the Composite sample

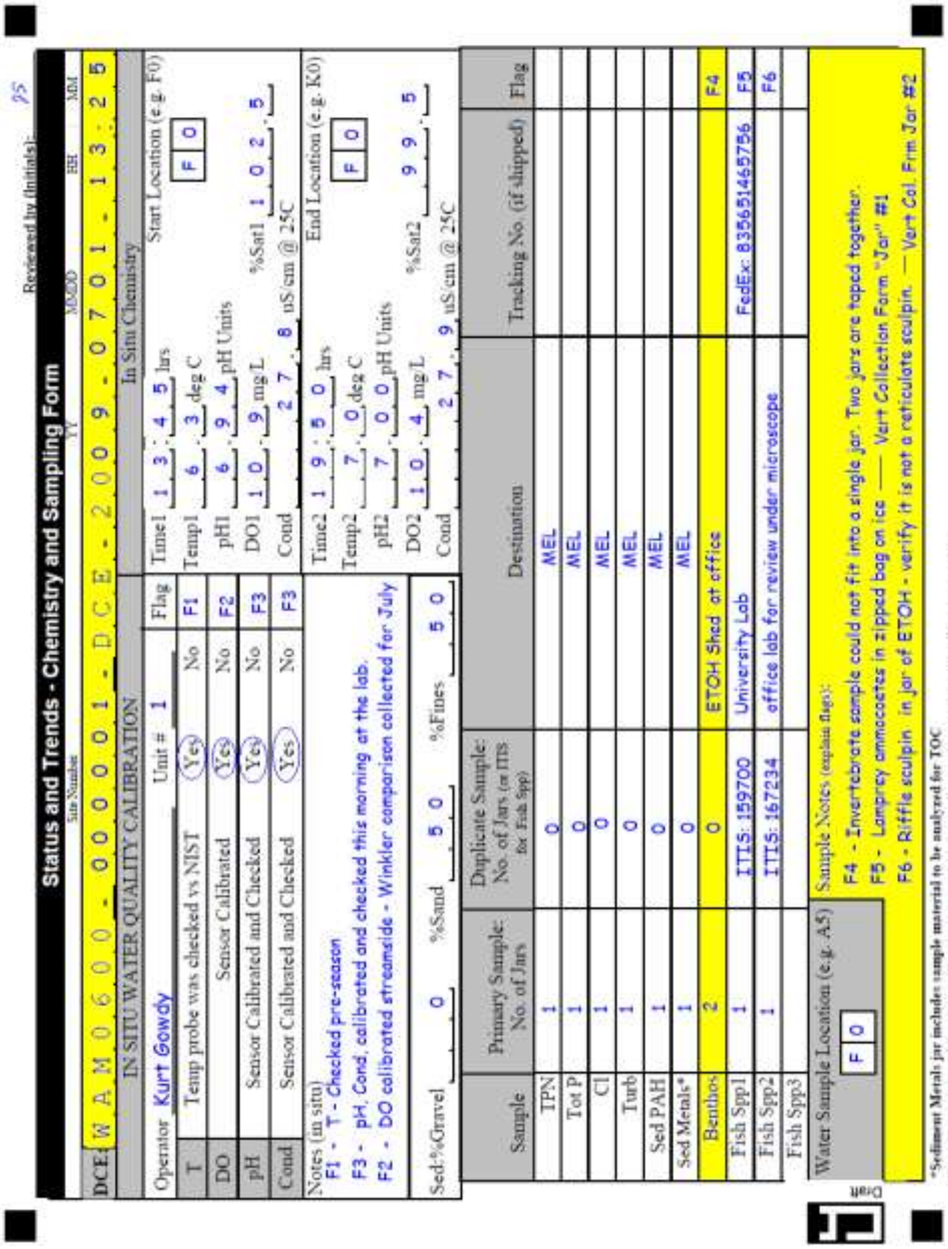
Using a number 2 pencil, complete two benthos jar labels (Figure G-1). Place one into the sample. Screw on the lid and seal it closed using electrical tape. Attach the other benthos label to the outside of the jar using clear tape. Record the DCE, which includes the Site_ID, and site arrival time (year, month, day, hour, and minute). It should match the DCE recorded on the Site Verification Form. Be sure to note which transects were sampled, and which of these were sampled using the slack water technique..

Figure G-1. The benthos jar label

500 µ D-frame kick	**Benthos Jar Label** Jar ___ of ___
Project	2009 Monitoring in the ____________________ STR
Stream	
Who collected? (full name)	
8 1-ft^2 Transects **(circle all sampled)**	A B C D E F G H I J Transects sampled using slack-water technique: ______________________
Collectors Notes	
DCE	WAM06600-__ __ __ __ __ __-dce-2009__ __ __ __-__ __ __ __ m m d d h h m m

Enter Data to the Chemistry and Sampling Form

The sample jars will be stored by field crews and delivered *en mass* to the analytical laboratory at the end of the field season. The Chemistry and Sampling Form (Figure G-2) will be used to keep track of sample jar information. Note the SampleID and number of jars per SampleID. If there is more than one jar for a SampleID, then ensure that the jars are located together. Taping the jars together with clear tape may be helpful. For destination, note the immediate place to where the sample will be stored, shipped, or delivered.



Status and Trends - Chemistry and Sampling Form

Reviewed by (Initials): JS

DCE W A M 0 6 0 0 - 0 0 0 0 0 1 - D C E - 2 0 0 9 - 0 7 0 1 - 1 3 : 2 5 (Site Number, YY, MMDD, HH, MM)

IN SITU WATER QUALITY CALIBRATION

Operator: Kurt Gowdy — Unit # 1

T	Temp probe was checked vs NIST	Yes	No	F1
DO	Sensor Calibrated	Yes	No	F2
pH	Sensor Calibrated and Checked	Yes	No	F3
Cond	Sensor Calibrated and Checked	Yes	No	F3

In Situ Chemistry

Time1 13:45 hrs; Temp1 6.3 deg C; pH1 6.94 pH Units; DO1 10.9 mg/L, %Sat1 102.5; Cond 27.8 uS/cm @ 25C; Start Location (e.g. F0): F0

Notes (in situ):
F1 - T - Checked pre-season
F3 - pH, Cond, calibrated and checked this morning at the lab.
F2 - DO calibrated streamside - Winkler comparison collected for July

Time2 19:50 hrs; Temp2 7.0 deg C; pH2 7.00 pH Units; DO2 10.4 mg/L, %Sat2 99.5; Cond 27.9 uS/cm @ 25C; End Location (e.g. K0): F0

Sed:%Gravel 0 %Sand 50 %Fines 50

Sample	Primary Sample: No. of Jars	Duplicate Sample: No. of Jars (or ITIS for Fish Spp)	Destination	Tracking No. (if shipped)	Flag
TPN	1	0	MEL		
Tot P	1	0	MEL		
Cl	1	0	MEL		
Turb	1	0	MEL		
Sed PAH	1	0	MEL		
Sed Metals*	1	0	MEL		
Benthos	2	0	ETOH Shed at office		F4
Fish Spp1	1	ITIS: 159700	University Lab	FedEx: 835651465756	F5
Fish Spp2	1	ITIS: 167234	office lab for review under microscope		F6
Fish Spp3					

Water Sample Location (e.g. A5): F0

Sample Notes (explain flags):
F4 - Invertebrate sample could not fit into a single jar. Two jars are taped together.
F5 - Lamprey ammocoetes in zipped bag on ice — Vert Collection Form "Jar" #1
F6 - Riffle sculpin in jar of ETOH - verify it is not a reticulate sculpin. — Vert Col. Frm Jar #2

*Sediment Metals jar includes sample material to be analyzed for TOC
Note: Use standard Manchester Environmental Lab forms for tracking water and sediment samples.

Draft

Figure G-2. The Chemistry and Sampling Form, with fields that are relevant to benthos sampling highlighted.

References

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http://www.pnamp.org/web/workgroups/SC/meetings/2007_0821/2007_0531PNAMP_macroinvert_protocol_final.pdf

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http://www.epa.gov/wed/pages/publications/authored/EPA620R-06003EMAPSWFieldOperationsManualPeck.pdf

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Appendix H

Bank Measurements at Major Transects in Waded Streams

Purpose and Scope

This method explains how to collect measurements for the Status and Trends Program at each of 11 equidistant transects at each site. Measurements in this procedure will be restricted to one main channel.

Instruments included on the procedure include distance measuring devices (e.g., measuring rod, laser rangefinder, 50-m measuring tape), and hand-levels.

Definitions

Definitions of acronyms and other terms are found in Table H-1.

Table H-1. Definitions.

Term or Accronym	**Definition**
bankfull depth	This is the sum of thalweg wetted depth and bankfull height.
bankfull height	Vertical distance between surface of water and bankfull stage. For Status and Trends, this is measured in centimeters.
bankfull stage	This stage is delineated by the elevation point of incipient flooding, indicated by deposits of sand or silt at the active scour mark, break in stream bank slope, perennial vegetation limit, rock discoloration, and root hair exposure (Endreny 2009).
bankfull width	Horizontal distance between the bankfull stage on the left bank and the bankfull stage on the right bank. For Status and Trends, this is measured in tenth of meters.
bar	A dry area within the wetted channel. It does not extend vertically as high as the bankfull stage.
DCE	Data Collection Event. Data are indexed using this code which includes the SITE_ID, the date, and the time that the event began. It uses this format:

	WAM06600-NNNNNN-dce-20YY-MMDD-HHMM **NNNNNN** = the number portion of the SITE_ID. **YY** = the last two numeric digits of the year that the event occurred. **MM** = the two numeric digits for the month that the event occurred. **DD** = the two numeric digits for the day within the month that the event occurred. **HHMM** = the military time when the event began.
floodplain	The part of the valley floor over which a river spreads during seasonal or short-term floods (Small and Witherick 1986)
island	A dry area between channels. It extends vertically at least as high as the bankfull stage.
left bank	A person facing downstream will have the left bank on their left side.
main channel	Channels in a stream are divided by islands (dry ground that rises above bankfull stage). Main channels contain the greatest proportion of flow. For this method it is called channel number 0.
major transect	One of 11 equidistant transects across the length of a site. These are labeled as follows: A0 (lowest), B0,C0,….K0 (highest) A major transect will cross the main channel and side channels.
right bank	A person facing downstream will have the right bank on their right side.
side channels	Channels that contain less flow than the main channels. These are identified and enumerated (1,2,3 etc.) as encountered (see the method for thalweg measurements) during the DCE.
site	A site is defined by the coordinates provided to a sampling crew and the boundaries established by the site layout method. Typically, the site extends 10 bankfull widths downstream from the coordinates and 10 bankfull widths upstream. The site also includes all riparian plots examined during the *Data Collection Event*. The site consists of many stations at which measurements or samples are collected.
station	Any location within the site where an observation is made or part of a sample is collected.
thalweg	Path of a stream that follows the deepest part of the channel (Armantrout, 1998).
thalweg transect	One of 101 equidistant transects across the length of a site. Labeling includes the name of the major transect. For example the thalweg transects between (and including) major transects A0and B0 would be labeled as follows: A0, A1, A2, A3, A4, A5, A6, A7, A8, A9, B0

	(i.e.., thalweg transect A0 is identical to major transect A0)
transect	A line of study that crosses the direction of flow, divided into intervals where observations are collected.
wetted width	Farthest horizontal distance between water edge on the left and right sides of a channel.

Personnel Responsibilities

This method is performed by 2 persons. This method is applied at every DCE, at each major transect. Staff performing this method must have been trained.

Equipment, Reagents, Supplies

- No. 2 pencil
- measuring rod
- 50-m tape
- laser rangefinder
- hand level
- clinometer
- calculator

Summary of Procedure

Refer to the *Major Transect Form* (Figures H-1 and H-2). At each of the major Transects (A0-K0), assess the main channel. Measure these channel characters: bankfull width, wetted width, bar width, bankfull height, and bank instability. Describe flags.

BANK		Flag
Wetted Width XXX.X m	3.2	
Bar Width XX.X m	0	
Bankfull Width XXX.X m	5.4	
R Bankfull Height cm	35	
L BankfullHeight cm	32	
LB Instability %	50	F1
RB Instability %	0	

Figure H-1. A portion of the *Major Transect Form*, with example data for this method.

Flag	Comments
F1	slumping bank with cow prints

Figure H-2. A portion of the *Major Transect Form*, with an example flag qualifier**.**

Channel Dimensions

Bankfull Stage

At the transect, visually estimate the bankfull stage. This is best done after considerable training. There are at least four good on-line sources of training materials for identifying bankfull stage:

1. http://preview.tinyurl.com/8aabbm (Buffington 2007)
2. http://www.dnr.wa.gov/Publications/fp_bfw_video_pt1.wmv
   http://www.dnr.wa.gov/Publications/fp_bfw_video_pt2.wmv (Grizzel 2008)
3. http://www.stream.fs.fed.us/publications/bankfull_west.html (Leopold et al 1995)
4. http://www.fgmorph.com/fg_3_5.php (Endreny 2009)

Use this visual estimate to help understand where to measure *bankfull width* and *bankfull height*.

Bankfull Width

After locating the bankfull stage at each bank, measure the ***bankfull width*** (Figure H-2) to the nearest tenth of a meter. Record this value on the *Major Transect Data Form* (Figure H-1). Width measurements can be made using either a 50-m tape, a measuring rod, or (if the channel is wide) with a laser rangefinder.

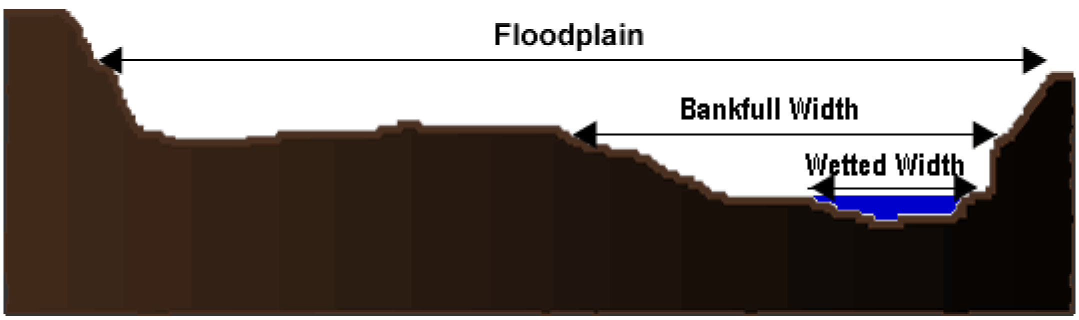

Figure H-2. Diagram of widths at the transect (Modified from Endreny 2009).

Wetted Width

Observe the wetted margins of the channel. On the *Major Transect Data Form* (Figure H-1), record the ***wetted width*** (or horizontal distance between these margins) to the nearest tenth of a meter. Do *not* subtract for bars.

Bar Width

Using the measuring rod, measure the width of each bar within the wetted channel. Record the sum (nearest tenth of a meter) for ***bar width***.

Bankfull Height

Bankfull height is measured using a surveyor's rod with hand level or clinometer. On the *Major Transect Form* (Figure H-1), record bankfull height data in whole centimeters. Record the ***right bankfull height*** and ***left bankfull height*** (Figure H-4).

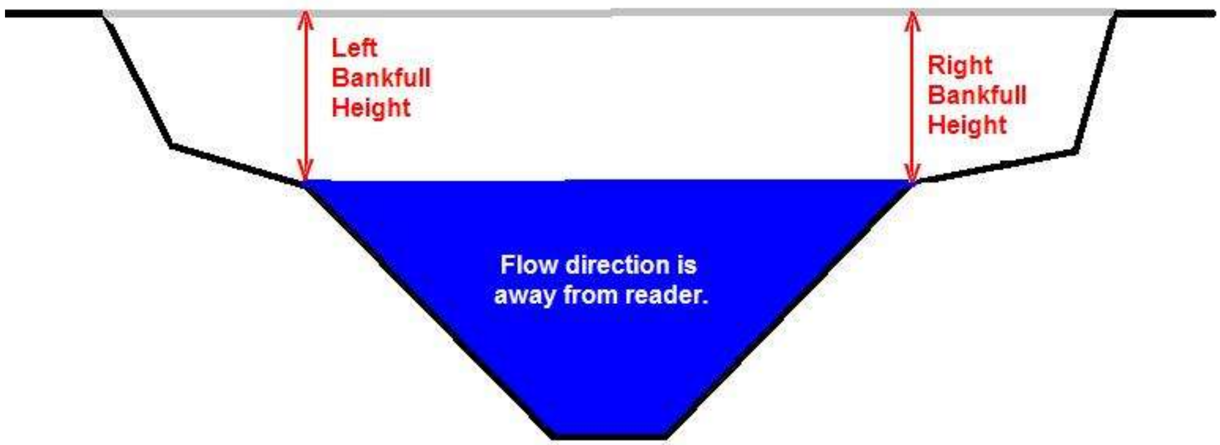

Figure H-4. Diagram of the left and right bankfull height measurements.

Bank Instability

For waded streams, evaluate how much of a 10-m length of each bank (centered on the primary transect) is unstable. Limit your observations of bank stability to the portion of the bank at and below the bankfull stage.

A bank is unstable if it has eroding or collapsing banks. It may have the following characteristics:

- sparse vegetation on a steep surface
- tension cracks
- sloughing

On the *Major Transect Form* (Figure H-1), record ***right bank instability*** (%) and ***left bank instability*** (%).

References

Buffington, J.M. 2007. Identifying Bankfull Elevation. Pacific Northwest Aquatic Monitoring Partnership (PNAMP) Watershed Monitoring Workgroup meeting attachment for 1 February 2007.
http://www.pnamp.org/web/Workgroups/documents.cfm?strWGShort=WM

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Appendix I

Substrate and Depth Measurements at Major Transects in Waded Streams

Purpose and Scope

This method explains how to measure substrate characteristics for the Status and Trends Program at each of 11 equidistant transects at each site. Measurements in this procedure will be restricted to one main channel. This method must be preceded by the Major Transects Method.

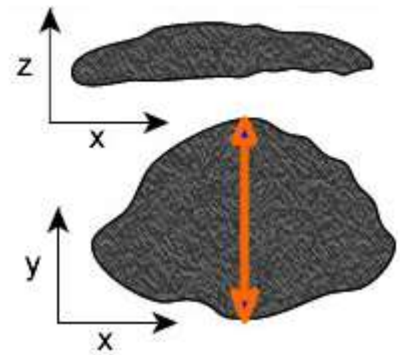
Instruments included on the procedure include distance measuring devices (e.g., measuring rod, or 50-m measuring tape, caliper), leveling device (hand level or clinometer) and a10-cm PVC ring.

Definitions

Definitions of acronyms and other terms are found in Table I-1.

Table I-1. Definitions.

Term or Acronym	**Definition**
bankfull depth	This is the vertical distance between the channel bed surface and the mean height of bankfull stage.
bankfull height	Vertical distance between surface of water and bankfull stage. For Status and Trends, this is measured in centimeters. It is measured at the left and right wetted margins of each major transect and a mean value is computed for each channel at that transect.
bankfull stage	This stage is delineated by the elevation point of incipient flooding, indicated by deposits of sand or silt at the active scour mark, break in stream bank slope, perennial vegetation limit, rock discoloration, and root hair exposure (Endreny 2009).
bankfull width	Horizontal distance between the bankfull stage on the left bank and the bankfull stage on the right bank. For Status and Trends, this is measured in tenth of meters.
intermediate axis	The diameter of a particle that is neither the longest nor the shortest of mutually perpendicular axes (Bain 1999, Harrelson et al 1994). See below for a diagram from Endreny (2009):

	
left bank	A person facing downstream will have the left bank on their left side.
main channel	Channels in a stream are divided by islands (dry ground that rises above bankfull stage). Main channels contain the greatest proportion of flow. For this method it is called channel number 0.
major transect	One of 11 equidistant transects across the length of a site. These are labeled as follows: A0 (lowest), B0,C0,….K0 (highest) A major transect will cross the main channel and side channels.
right bank	A person facing downstream will have the right bank on their right side.
side channels	Channels that contain less flow than the main channels. These are identified and enumerated (1,2,3 etc.) as encountered (see the method for thalweg measurements) during the data collection event.
site	A site is defined by the coordinates provided to a sampling crew and the boundaries established by the site layout method. Typically, the site extends 10 bankfull widths downstream from the coordinates and 10 bankfull widths upstream. The site also includes all riparian plots examined during the *Data Collection Event*. The site consists of many stations at which measurements or samples are collected.
station	Any location within the site where an observation is made or part of a sample is collected.
transect	A line of study that crosses the direction of flow, divided into intervals where observations are collected.
wetted width	Farthest horizontal distance between water edge on the left and right sides of a channel.

Personnel Responsibilities

This method is performed by 2 persons. This method is applied at every DCE, at each major transect. Staff performing this method must have been trained.

Equipment, Reagents, Supplies

- No. 2 pencil
- measuring rod
- 50-m tape
- PVC ring
- hand-level
- clinometer
- calculator

Summary of Procedure

Refer to the *Major Transect Data Form* (Figure I-1). At each of the major Transects (A0-K0), assess the main channel (channel number 0). Record these characters at each of 11 equidistant stations across the bankfull width:

- wetted depth
- bankfull depth
- substrate type code
- embeddedness.

Station Location

Identify the position along the transect. Example stations along a transect would be:

1. **left bank** – at the left bankfull stage
2. **.1** – 10% distance across the channel
3. **.2** – 20% distance across the channel
4. **.3** – 30% distance across the channel
5. **.4** – 40% distance across the channel
6. **.5** – half way across the channel
7. **.6** – 60% distance across the channel
8. **.7** – 70% distance across the channel
9. **.8** – 80% distance across the channel
10. **.9** – 90% distance across the channel
11. **right bank** – at the right bankfull stage

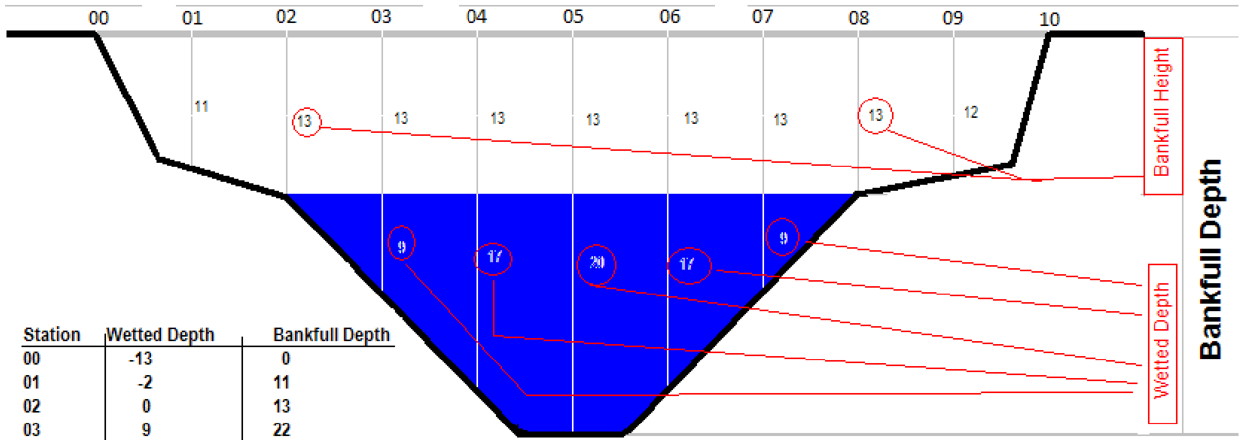
On the Major Transect Form (Figure I-1), insert data for depths, substrate type and embeddedness next to each station code. Describe flags (figure I-2). Examples of data can be found in Figures I-1, I2, and I-3.

SUBSTRATE					
	Wet Depth	BF Depth XXX CM	Size Class	Embd. 0-100%	Flag
left bank	-13	0	SA	100	
.1	-2	11	GF	90	
.2	0	13	GC	50	
.3	9	22	CB	25	
.4	17	30	SB	5	
.5	20	33	CB	25	
.6	17	30	CB	10	
.7	9	22	GC	10	
.8	0	13	WD	90	F1
.9	-1	12	FN	100	
right bank	-13	0	SA	100	

Figure I-1. Part of the *Major Transect Form* with example data for this method.

Flag	Comments
F1	WD = partially buried Douglas fir log, about 60 cm diameter

Figure I-2. Part of the *Major Transect Form* with example flag descriptions.



Station	Wetted Depth	Bankfull Depth
00	-13	0
01	-2	11
02	0	13
03	9	22
04	17	30
05	20	33
06	17	30
07	9	22
08	0	13
09	-1	12
10	-13	0

Figure I-3. Transect diagram showing example data for wetted depth, bankfull depth, and bankfull height. The bankfull depth equals the wetted depth plus average bankfull height.

Station Depth

For each station, record depth in whole centimeters. This should be the easiest to measure of either ***wetted depth*** or ***bankfull depth***. The bankfull depth equals the wetted depth plus average bankfull height. Therefore, if you know one type of depth and the mean bankfull height, you also know the other type of depth.

Substrate Type

After recording depth, estimate the substrate particle type at the front of the measuring rod, where it rests on the surface of the streambed. Estimate the size class of that particle based on the intermediate axis length. Record the ***substrate type code***. The choices are listed in Table I-1. For fine gravel, coarse gravel and cobble use calipers to measure the intermediate axis length of the particle and confirm your estimate of size. For larger sizes, use the measuring rod to confirm your estimate.

Particles smaller than 100 mm are evaluated using a 10 cm ring surrounding the sample point. All particles within the ring are evaluated for size and embeddedness, not just the point. Record the estimated average for surface substrate within the ring.

Table I-1. Substrate codes, types, and sizes.

CODE	TYPE	SIZE RANGE	SIZE GUAGE
RS	Bedrock (smooth)	> 4 m	larger than a car
RR	Bedrock (rough)	> 4 m	larger than a car
RC	Concrete/Asphalt	> 4 m	larger than a car
XB	Large Boulder	1-4 m	meter stick to car
SB	Small boulder	>250 mm – 1 m	basketball to meter stick
CB	Cobble	>64 mm – 250 mm	tennis ball to basketball
GC	Gravel, coarse	>16 mm to 64 mm	marble to tennis ball
GF	Gravel, fine	>2 mm to 16 mm	ladybug to marble
SA	Sand (2-16 mm)	>0.06 mm to 2 mm	gritty to ladybug
FN	Fines (silt/clay/muck)	< 0.06 mm	non gritty
HP	Hardpan - hardened fines	any size	
WD	Wood	any size	
OT	Other (doesn't fit choices above)	any size	

Embeddedness

At each station, touch the nearest particle to foot of the measuring rod then look at it. Estimate ***embeddedness*** (%). This is the fraction of a particle's surface that is surrounded by (embedded in) sand or finer sediments (≤ 2 mm). By default, sand or fines are 100% embedded. By default, bedrock is 0% embedded.

Particles smaller than 100 mm are evaluated using a 10 cm ring surrounding the sample point. All particles within the ring are evaluated for size and embeddedness, not just the point. Record the estimated average for surface substrate within the ring.

References

Bain, M.B. 1999. Substrate. Pages 95 to 103 *in* M.B. Bain and N.J. Stevenson, editors. Aquatic habitat assessment: common methods. American Fisheries Society, Bethesda, Maryland.

Endreny, T.A. 2009. *Fluvial Geomorphology Modules*, State University of New York College of Environmental Science and Forestry, National Oceanic and Atmospheric Administration, and the University Corporation for Atmospheric Research. www.fgmorph.com

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Appendix J

Shade Measurements at Major Transects in Waded Streams

Purpose and Scope

This method explains how to measure shade for the Status and Trends Program at each of 11 equidistant transects at each site. Measurements in this procedure will be restricted to one main channel. This method must be preceded by the Major Transects Method.

Instruments included on the procedure include a distance measuring device (e.g., measuring rod), and a convex densiometer (modified according to Mulvey *et al.* (1992)).

Definitions

Definitions of acronyms and other terms are found in Table J-1.

Table J-1. Definitions.

Term or Accronym	**Definition**
bankfull channel width	Horizontal distance between the bankfull stage on the left bank and the bankfull stage on the right bank.
bankfull stage	This stage is delineated by the elevation point of incipient flooding, indicated by deposits of sand or silt at the active scour mark, break in stream bank slope, perennial vegetation limit, rock discoloration, and root hair exposure (Endreny 2009).
left bank	A person facing downstream will have the left bank on their left side.
main channel	Channels in a stream are divided by islands (dry ground that rises above bankfull stage). Main channels contain the greatest proportion of flow. For this method it is called channel number 0.
major transect	One of 11 equidistant transects across the length of a site. These are labeled as follows: A0 (lowest), B0,C0,….K0 (highest) A major transect will cross the main channel and side channels.
right bank	A person facing downstream will have the right bank on their right

	side.
station	Any location within the site where an observation is made or part of a sample is collected.
side channels	Channels that contain less flow than the main channels. These are identified and enumerated (1,2,3 etc.) as encountered (see the method for thalweg measurements) during the data collection event.
site	A site is defined by the coordinates provided to a sampling crew and the boundaries established by the site layout method. Typically, the site extends 10 bankfull widths downstream from the coordinates and 10 bankfull widths upstream. The site also includes all riparian plots examined during the *Data Collection Event*. The site consists of many stations at which measurements or samples are collected.
transect	A line of study that crosses the direction of flow, divided into intervals where observations are collected.

Personnel Responsibilities

This method is performed by 1 person. This method is applied at every DCE, at each major transect. Staff performing this method must have been trained.

Equipment, Reagents, Supplies

- No. 2 pencil
- *Major Transect Form*
- measuring rod or 50-m tape
- Modified convex densiometer

Summary of Procedure

Refer to the *Major Transect Form* (Figure J-1). At each of the major Transects (A0-K0), assess the main channel (channel number 0). Use a convex densiometer (Lemmon, 1957) that has been modified according to Mulvey *et al* (1992; figure J-2); it has 17 intersections.

DENSIOMETER MEASUREMENTS

(0-17Max)

		Flag			Flag
CenUp	5		CenR	9	
CenL	0		Left	0	
CenDwn	4		Right	17	

Figure J-1. Densiometer portion of The *Major Transects Form*, with example data.

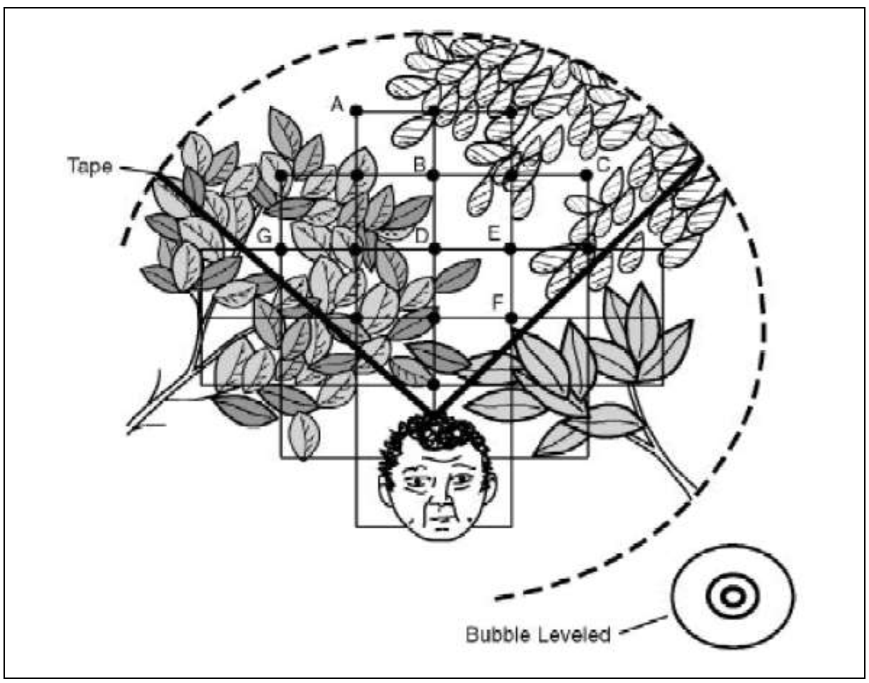

Figure J-2. An example reading from a modified convex densiometer. It shows 10 of 17 intersections with shade (a score of "10"). Note the proper positions of the bubble and head reflection (From Mulvey *et al*. 1992).

Record how many of the 17 cross-hairs have shade over them. Do this for each of six directions on the major transect (Figure J-3):

- Facing the left bankfull stage

- Facing the right bankfull stage
- Bankfull channel center, facing upstream
- Bankfull channel center, facing right
- Bankfull channel center, facing downstream
- Bankfull channel center, facing left

At each wetted station, hold the densiometer 30 cm above the water. At each dry station, hold the densiometer 30 cm above the ground. Bank readings should be able to detect shade from riparian understory vegetation such as ferns.

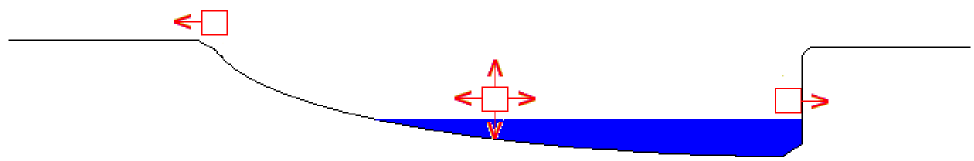

Figure J-3. Stations for densiometer measurement on each major transect. The densiometer is held level, and 30 cm above water for wet stations and 30 cm above ground for dry stations.

References

Endreny, T.A. 2009. *Fluvial Geomorphology Modules*, State University of New York College of Environmental Science and Forestry, National Oceanic and Atmospheric Administration, and the University Corporation for Atmospheric Research. www.fgmorph.com

Lemmon, P.E. 1957. A New Instrument for Measuring Forest Overstory Density. Journal of Forestry. 55(9):667-668.

Mulvey, M, L. Caton, and R. Hafele. 1992. Oregon Nonpoint Source Monitoring Protocols and Stream Bioassessment Field Manual for Macroinvertebrates and Habitat Assessment, Draft. Oregon Department of Environmental Quality, Portland, Oregon.

Appendix K

Estimating Fish Cover at Major Transects in Waded Streams

Purpose and Scope

This method explains how to estimate fish cover for the Status and Trends Program at each of 11 equidistant transects at each site. Measurements in this procedure will be restricted to one main channel. This method must be preceded by the Major Transects Method.

Instruments included on the procedure include a distance measuring device (e.g., measuring rod).

Definitions

Definitions of acronyms and other terms are found in Table K-1.

Table K-1. Definitions.

Term or Accronym	**Definition**
Artificial structures	For this method: potential cover for aquatic vertebrates provided by human-introduced objects.
Boulders	For this method: potential cover for aquatic vertebrates provided by rocks over basketball-size.
Brush (dead)	For this method: potential cover for aquatic vertebrates provided by dead pieces of wood that are < 10 cm diameter *or* < 2 m long
Bryophytes	For this method: potential cover for aquatic vertebrates provided by non-vascular plants such as mosses that reproduce using spores.
DCE	Data Collection Event. Data are indexed using this code which includes the SITE_ID, the date, and the time that the event began. It uses this format: **WAM06600-NNNNNN-dce-20YY-MMDD-HHMM** **NNNNNN** = the number portion of the SITE_ID. **YY** = the last two numeric digits of the year that the event occurred. **MM** = the two numeric digits for the month that the event occurred.

	DD = the two numeric digits for the day within the month that the event occurred. **HHMM** = the military time when the event began.
Filamentous algae	For this method: potential cover for aquatic vertebrates provided by long, streaming filaments of microscopic algal cells that often occur in eutrophic water. Not to be confused with macrophytes and flowering aquatic plants.
Live trees/Roots	For this method: potential cover for aquatic vertebrates provided living woody vegetation that is within the water.
Macrophytes	For this method: potential cover for aquatic vertebrates provided by floating, submerged, or emergent water loving plants and wetland grasses that could provide cover for fish or macroinvertebrates. This category excludes mosses.
Main channel	Channels in a stream are divided by islands (dry ground that rises above bankfull stage). Main channels contain the greatest proportion of flow. For this method it is called channel number 0.
major transect	One of 11 equidistant transects across the length of a site. These are labeled as follows: A0 (lowest), B0,C0,….K0 (highest). A major transect will cross the main channel and side channels.
Overhanging Vegetation	For this method: potential cover for aquatic vertebrates provided by vegetation that hangs to within 1 m of the water surface. Higher vegetation (e.g. perches for kingfishers or other predators) does not count.
Side channels	Channels that contain less flow than the main channels. These are identified and enumerated (1,2,3 etc.) as encountered (see the method for thalweg measurements) during the data collection event.
site	A site is defined by the coordinates provided to a sampling crew and the boundaries established by the site layout method. Typically, the site extends 10 bankfull widths downstream from the coordinates and 10 bankfull widths upstream. The site also includes all riparian plots examined during the *Data Collection Event*. The site consists of many stations at which measurements or samples are collected.
Transect	A line of study that crosses the direction of flow, divided into intervals where observations are collected.
Undercut banks	For this method: potential cover for aquatic vertebrates provided by banks (at the wetted margin) that extend over deeper water. Fish cover assessment is by area, rather than length. Therefore undercut banks rarely provide more than 10% cover for a plot.
Woody debris (dead)	For this method: potential cover for aquatic vertebrates provided dead pieces of wood that are ≥ 10 cm diameter *and* ≥ 2 m long.

Personnel Responsibilities

This method is performed by 1 person. This method is applied at every DCE, at each major transect. Staff performing this method must have been trained.

Equipment, Reagents, Supplies

- No. 2 pencil
- *Major Transect Form*
- measuring rod or 50-m tape

Summary of Procedure

This method is derived from that of Peck *et al.* (2006).

Within the main channel, evaluate 11 plots (Figure K-1) with these characteristics:

- Centered at each major transect
- Extends 5 meters upstream of each transect
- Extends 5 meters downstream of each transect
- Beneath the wetted surface

Visually assess the percentage of the water surface that has fish cover provided by each of 10 cover types.

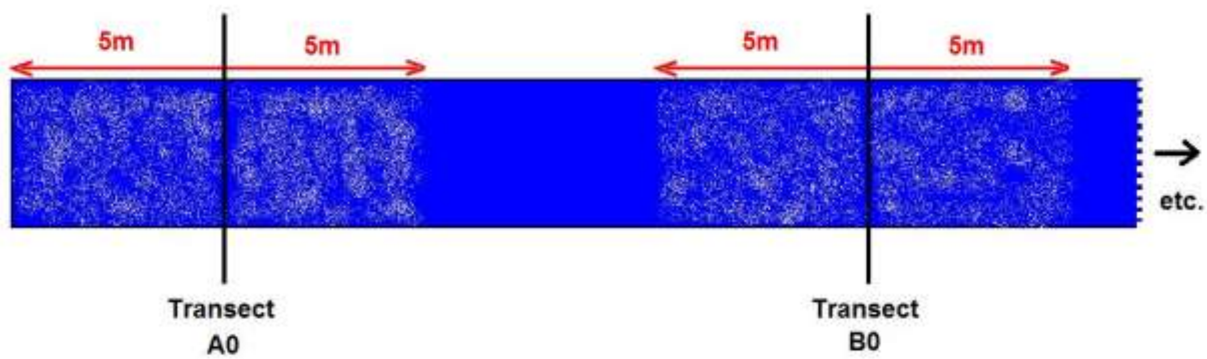

Figure K-1. Diagram of fish cover plots at each major transect of the main channel.

Refer to the *Major Transect Form* (Figure K-2). Circle the cover code that best characterizes each cover type.

FISH COVER	0 = Absent (0%) 1 = Sparse (<10%) 2 = Moderate (10-40%) 3 = Heavy (40-75%) 4 = Very Heavy (>75%) (circle one)	
	Cover in Channel	Flag
Filamentous Algae	0 1 2 3 4	
Macrophytes	0 1 2 3 4	
Woody Debris	0 1 2 3 4	
Brush	0 1 2 3 4	
Live Trees or Roots	0 1 2 3 4	
Overhanging Veg. =<1 m of Surface	0 1 2 3 4	
Undercut Banks	0 1 2 3 4	
Boulders	0 1 2 3 4	
Artificial Structures	0 1 2 3 4	
Bryophytes	0 1 2 3 4	

Figure K-2. Fish Cover portion of The *Major Transects Form*, with example records.

References

Peck, D.V., Herlihy, A.T., Hill, B.H., Hughes, R.M., Kaufmann, P.R., Klemm, D.J., Lazorchak, J.M., McCormick, F.H., Peterson, S.A., Ringold, P.L., Magee, T., and Cappaert, M.R. Environmental Monitoring and Assessment Program-Surface Waters, Western Pilot Study, Field Operations Manual for Wadeable Streams. EPA/620/R-06/003. U.S. Environmental Protection Agency, Washington, D.C. http://www.epa.gov/wed/pages/publications/authored/EPA620R-06003EMAPSWFieldOperationsManualPeck.pdf

Appendix L

Human Influence at Major Transects in Waded Streams

Purpose and Scope

This method explains how to collect measurements for the Status and Trends Program at each of 11 equidistant transects at each site. Measurements in this procedure will be restricted to one main channel. This method must follow the method for establishing major transects.

Definitions

Definitions of acronyms and other terms are found in Table L-1.

Table L-1. Definitions.

Term or Accronym	**Definition**
Bankfull stage	This stage is delineated by the elevation point of incipient flooding, indicated by deposits of sand or silt at the active scour mark, break in stream bank slope, perennial vegetation limit, rock discoloration, and root hair exposure (Endreny 2009).
Left bank	A person facing downstream will have the left bank on their left side.
Main channel	Channels in a stream are divided by islands (dry ground that rises above bankfull stage). Main channels contain the greatest proportion of flow. For this method it is called channel number 0.
major transect	One of 11 equidistant transects across the length of a site. These are labeled as follows: A0 (lowest), B0,C0,….K0 (highest) A major transect will cross the main channel and side channels.
Right bank	A person facing downstream will have the right bank on their right side.
Side channels	Channels that contain less flow than the main channels. These are identified and enumerated (1,2,3 etc.) as encountered (see the method for thalweg measurements) during the DCE.

Personnel Responsibilities

This method is performed by 1 person. This method is applied at every DCE, at each major transect. Observations are made at each bank of the main channel. Staff performing this method must have been trained.

Equipment, Reagents, Supplies

- No. 2 pencil
- *Major Transect Data Form*
- measuring device (rod, tape, rangefinder)

Summary of Procedure

This procedure is derived from Peck et al. (2006) and Moberg (2007).

Refer to the *Major Transect Data Form* (Figures L-1 and L-2). At each of the major Transects (A0-K0), assess the main channel. Record the appropriate ***influence proximity code*** for each of 13 human ***influence types*** (Figure L-1) relative to riparian plots (Figure L-3) on each bank of the transect. Influence proximity codes are:

- 0 = absent
- 1 = beyond the plot, but within 30 meters of the bankfull margin.
- 2 = within the 10 meter by 10 m riparian plot.
- 3 = at least partially within the bankfull channel.

HUMAN INFLUENCE	0=not present, 1= 10-30m, 2= 0-10m, 3= on bank		
	Left Bank	Right Bank	Flag
Wall/Dike/Revetment/ Riprap/Dam	0 1 2 3	0 1 2 3	
Buildings	0 1 2 3	0 1 2 3	F1
Unpaved Motor Trail	0 1 2 3	0 1 2 3	
Clearing or Lot	0 1 2 3	0 1 2 3	
Human Foot Path	0 1 2 3	0 1 2 3	
PavedRoad/Railroad	0 1 2 3	0 1 2 3	
Pipes (Inlet/Outlet)	0 1 2 3	0 1 2 3	F2
Landfill/Trash	0 1 2 3	0 1 2 3	F3
Park/Lawn	0 1 2 3	0 1 2 3	
Row Crops	0 1 2 3	0 1 2 3	
Pasture/Range/Hay Field	0 1 2 3	0 1 2 3	
Logging Operations	0 1 2 3	0 1 2 3	
Mining Activity	0 1 2 3	0 1 2 3	

Figure L-1. A portion of the *Major Transect Form*, with example data.

Flag	Comments
F1	single-family home
F2	possible irrigation source
F3	beer cans

Figure L-2. A portion of the *Major Transect Form* with example comments for data flags.

PLOTS FOR WADED STREAMS

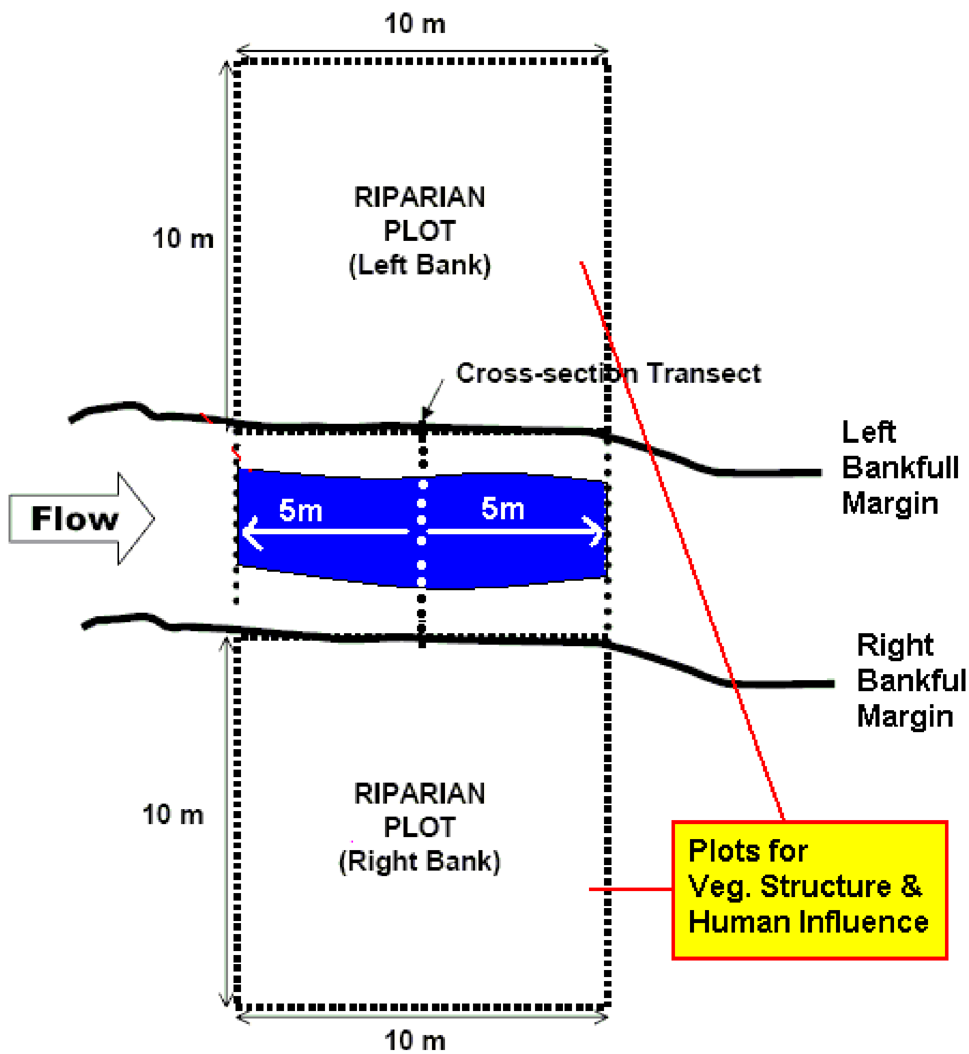

Figure L-3. Riparian plots

References

Moberg, J. 2007. A field manual for the habitat protocols of the Upper Columbia Monitoring Strategy. Prepared for and funded by Bonneville Power Administration's Integrated Status and Effectiveness Monitoring Program. Terraqua, Inc. Wauconda, WA http://www.nwfsc.noaa.gov/research/divisions/cbd/mathbio/isemp/docs/isemphabitatprotocolsfieldmanualdraft070615.pdf

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Appendix M

Riparian Vegetation Structure at Major Transects in Waded Streams

Purpose and Scope

This method explains how to collect measurements for the Status and Trends Program at each of 11 equidistant transects at each site. Observations in this procedure will be restricted to one main channel. This method must follow the method for establishing major transects.

Definitions

Definitions of acronyms and other terms are found in Table M-1.

Table M-1. Definitions.

Term or Acronym	Definition
Bankfull stage	This stage is delineated by the elevation point of incipient flooding, indicated by deposits of sand or silt at the active scour mark, break in stream bank slope, perennial vegetation limit, rock discoloration, and root hair exposure (Endreny 2009).
Broadleaf evergreen	Non-coniferous trees that maintain foliage through the seasons. A native example for Washington is the madrona (*Arbutus menziesii*)
Canopy	The functional definition for this method: Vegetation above 5 m high within a 10 m x 10 m riparian plot.
Coniferous	Any of various mostly needle-leaved or scale-leaved, chiefly evergreen, cone-bearing gymnospermous trees or shrubs such as pines, spruces, and firs. This includes larch.
Cover	This can be thought of as the amount of shadow cast by a particular layer alone when the sun is directly overhead. Conceptually remove vegetation from higher layers before estimating.
DCE	Data Collection Event. Data are indexed using this code which includes the SITE_ID, the date, and the time that the event began. It uses this format: **WAM06600-NNNNNN-dce-20YY-MMDD-HHMM** **NNNNNN** = the number portion of the SITE_ID. **YY** = the last two numeric digits of the year that the event occurred. **MM** = the two numeric digits for the month that the event occurred.

	DD = the two numeric digits for the day within the month that the event occurred. **HHMM** = the military time when the event began.
Deciduous	Non-coniferous trees that shed their leaves annually. Examples include alder, oak, maple, and cottonwood.
Duff	Organic matter in various stages of decomposition on the floor of the forest.
Forbs	A broad-leaved herb other than a grass, such as those that grow in a field, prairie, or meadow.
Ground cover	The functional definition for this method: Vegetation or bare ground below 0.5 m high within a 10 m x 10 m riparian plot.
Herbs	Plants whose stems do not produce woody, persistent tissue. They generally die back at the end of each growing season.
Left bank	A person facing downstream will have the left bank on their left side.
Main channel	Channels in a stream are divided by islands (dry ground that rises above bankfull stage). Main channels contain the greatest proportion of flow. For this method it is called channel number 0.
major transect	One of 11 equidistant transects across the length of a site. These are labeled as follows: A0 (lowest), B0,C0,….K0 (highest)
Mixed	Vegetation type if more than 10% of the cover is made up of an alternate type.
Right bank	A person facing downstream will have the right bank on their right side.
Side channels	Channels that contain less flow than the main channels. These are identified and enumerated (1,2,3 etc.) as encountered (see the method for thalweg measurements) during the DCE.
Understory	The functional definition for this method: Vegetation below 5 m high but above 0.5 m high within a 10 m x 10 m riparian plot.

Personnel Responsibilities

This method is performed by 1 person. This method is applied at every DCE, at each major transect. Observations are made at each bank of the main channel. Staff performing this method must have been trained.

Equipment, Reagents, Supplies

- No. 2 pencil
- *Major Transect Data Form*

Summary of Procedure

This procedure is derived from Peck et al. (2006) and Moberg (2007).

Refer to the *Major Transect Data Form* (Figure M-1).

RIPARIAN	0 = Absent (0%) 1 = Sparse (<10%) 2 = Moderate (10-40%) 3 = Heavy (40-75%) 4 = Very Heavy (>75%)	D = Deciduous C = Coniferous E = Broadleaf Evergreen M = Mixed N = None	
RIPARIAN VEGETATION COVER	Left Bank	Right Bank	Flag
	Canopy (>5 m high)		
Woody Vegetation Type	D C E M N	D C E M N	
BIG Trees (Trunk >0.3 m DBH)	0 1 2 3 4	0 1 2 3 4	
SMALL Trees (Trunk <0.3 m DBH)	0 1 2 3 4	0 1 2 3 4	
	Understory (0.5 to 5 m high)		
Woody Vegetation Type	D C E M N	D C E M N	
Woody Shrubs & Saplings	0 1 2 3 4	0 1 2 3 4	
Non-Woody Herbs, Grasses, & Forbs	0 1 2 3 4	0 1 2 3 4	
	Ground Cover (<0.5 m high)		
Woody Shrubs & Saplings	0 1 2 3 4	0 1 2 3 4	
Non-Woody Herbs, Grasses and Forbs	0 1 2 3 4	0 1 2 3 4	
Barren, Bare Dirt or Duff	0 1 2 3 4	0 1 2 3 4	

Figure M-1. A portion of the *Major Transect Data Form*, with example data.

On each major transect of the main channel, assess a plot on each bank. Each plot extends 5 meters downstream, 5 meters upstream, and 10 meters back from the bankfull margin. The riparian plot dimensions can be estimated rather than measured. On steeply sloping channel margins, plot boundaries are defined as if they were projected down from an aerial view.

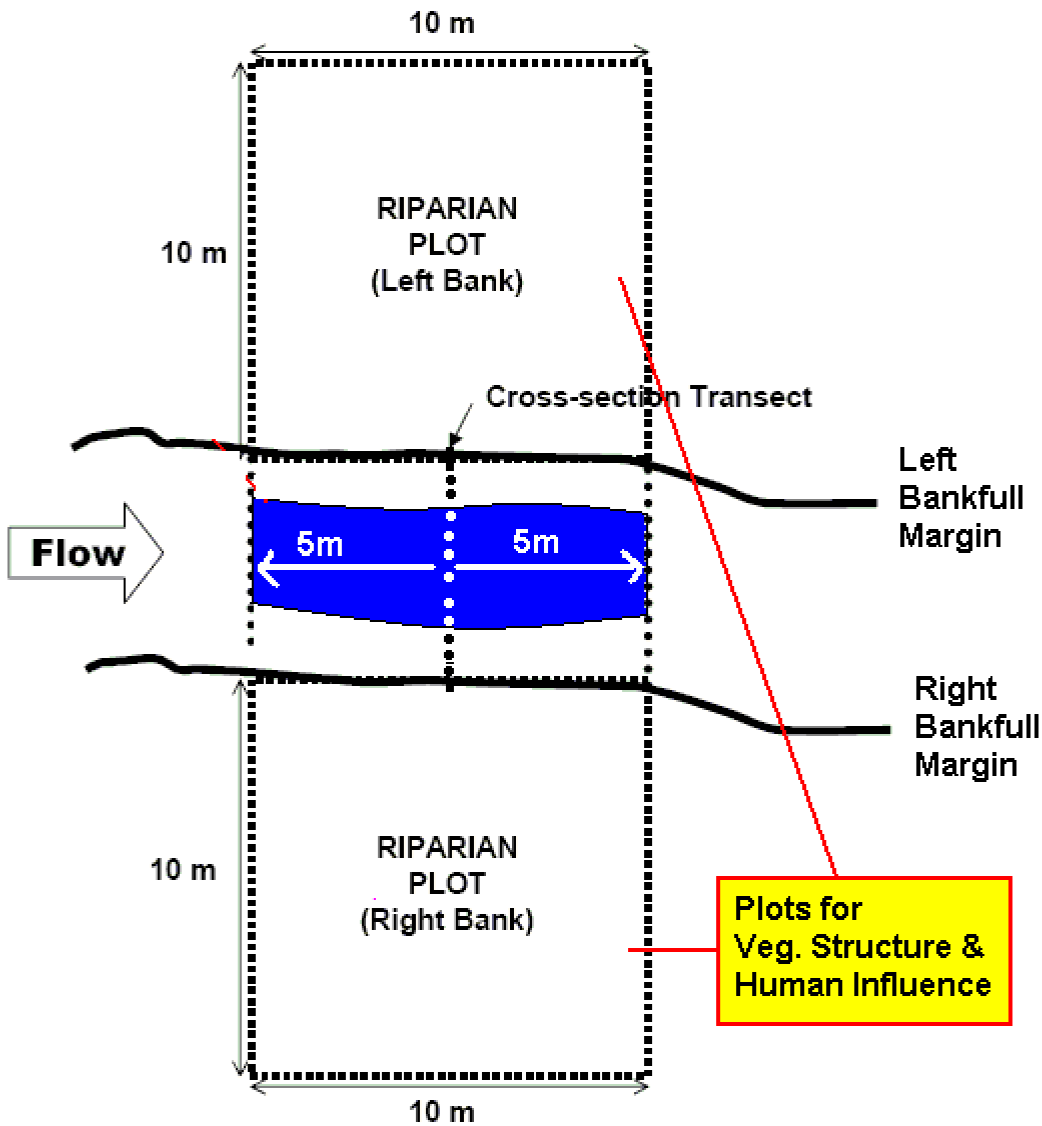

Figure M-2. Riparian plots

Conceptually divide the riparian vegetation into three layers:

- Canopy (> 5 m high),
- Understory (0.5 to 5 m high),
- Ground Cover layer (< 0.5 m high).

Within each layer, consider the type of vegetation present and the amount of cover provided. Do this independently of what is contained in higher layers.

Cover quantity is coded on the field form (Figure I-1) as follows:

- 0 - absent
- 1- sparse (< 10% cover)
- 2 - moderate (10-40% cover)
- 3 - heavy (40-75% cover)
- 4 – very heavy (> 75% cover)

The maximum cover in each layer is 100%, so the sum of the cover for the combined three layers could add up to 300%.

Canopy

On the *Major Transect Form* (Figure I-1), circle the appropriate vegetation **type code** (D, C, E, M, or N). Type codes are defined on the form.

Then circle the appropriate cover **quantity code** (0, 1, 2, 3, or 4) for each of 2 classes:

- Big trees – trees having trunks larger than 0.3 m diameter (at breast height)
- Small trees– trees having trunks smaller than 0.3 m diameter (at breast height)

Understory

On the *Major Transect Form* (Figure I-1), circle the appropriate vegetation **type code** (D, C, E, M, or N) for any *woody* vegetation that might be present. Then circle the appropriate cover **quantity code** (0, 1, 2, 3, or 4) for each of 2 classes:

- Woody vegetation - such as shrubs or saplings
- Non-woody vegetation - such as herbs, grasses, or forbs

Ground Cover

Circle the appropriate cover **quantity code** (0, 1, 2, 3, or 4) for each of 3 classes:

- Woody (living)
- Non-woody (living)
- Bare dirt (or decomposing debris)

The sum of cover quantity ranges for these 3 types of ground cover should include 100%.

References

Endreny, T.A. 2009. *Fluvial Geomorphology Modules*, State University of New York College of Environmental Science and Forestry, National Oceanic and Atmospheric Administration, and the University Corporation for Atmospheric Research. www.fgmorph.com

Moberg, J. 2007. A field manual for the habitat protocols of the Upper Columbia Monitoring Strategy. Prepared for and funded by Bonneville Power Administration's Integrated Status and Effectiveness Monitoring Program. Terraqua, Inc. Wauconda, WA http://www.nwfsc.noaa.gov/research/divisions/cbd/mathbio/isemp/docs/isemphabitatprotocolsfieldmanualdraft070615.pdf

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Appendix N

Measuring Thalweg Depth in Waded Streams

Purpose and Scope

This method explains how to collect incremental depth measurements for the Status and Trends Program when traversing the length of the stream site. It also describes assessing the presence of bars and edge pools. Observations in this method will be restricted to the main channel.

Definitions

Definitions of acronyms and other terms are found in Table N-1.

Table N-1. Definitions.

Term or Acronym	Definition
bankfull stage	This stage is delineated by the elevation point of incipient flooding, indicated by deposits of sand or silt at the active scour mark, break in stream bank slope, perennial vegetation limit, rock discoloration, and root hair exposure (Endreny 2009).
bankfull width	Horizontal distance between the bankfull stage on the left bank and the bankfull stage on the right bank. For Status and Trends, this is measured in tenth of meters.
bar	Bars are dry or exposed portions of the streambed. For this method, we are only counting bars that are surrounded by water (e.g. mid-channel bars or diamond bars). Bars are lower in elevation than the bankfull stage (islands are higher).
edge pool	Slow water at the edge of the wetted channel (but connected) where velocity is slow and often in a separate direction from the main flow. Imagine a line along the wetted edge of the wetted channel that is conceptually drawn across the mouth of the edge pool. The depth somewhere behind that line must be at least 30 cm. Edge pools must be at least 0.5 m long behind that imaginary line. Examples of edge pools include backwater pools, secondary channel pools, or alcoves that meet the size criteria described above.
left bank	A person facing downstream will have the left bank on their left side.
main channel	Channels in a stream are divided by islands (dry ground that rises above bankfull stage). Main channels contain the greatest proportion of flow. For this method it is called channel number 0.

major transect	A subset of the thalweg transects. Each of 11 equidistant transects across the length of a site. These are labeled as follows: A0 (lowest), B0, C0….K0 (highest).
right bank	A person facing downstream will have the right bank on their right side.
thalweg	Path of a stream that follows the deepest part of the channel (Armantrout, 1998).
thalweg depth	Water depth along the path of the thalweg.
thalweg transect	The stream site is conceptually divided longitudinally into 100 segments, separated by 101 thalweg transects. Thalweg transects are separated by 0.2 (site average) bankfull widths from each other. The thalweg transects are labeled from the bottom of the site to the top as follows: A0, A1, A2, A3, A4, A5, A6, A7, A8, A9, B0…K0.

Personnel Responsibilities

This method is performed by 2 persons: one measures and another records. This method is limited to the main channel. It must be preceded by the method for verification and site layout. Staff performing this method must have been trained.

Equipment, Reagents, Supplies

- No. 2 pencil
- *Thalweg Data Form*
- Measuring rod

Summary of Procedure

This procedure is derived from Peck et al. (2006) and Moberg (2007).

Refer to the *Thalweg Data Form* (Figure N-1).

Transect A	Thalweg Depth (cm)	Bar? (circle)	Edge Pool? (circle)
.0	69	Y N	Y N
.1	70	Y N	Y N
.2	75	Y N	Y N
.3	87	Y N	Y N
.4	70	Y N	Y N
.5	75	Y N	Y N
.6	33	Y N	Y N
.7	34	Y N	Y N
.8	32	Y N	Y N
.9	33	Y N	Y N

Figure N-1. A portion of the *Thalweg Data Form*, with example data.

While walking up the main channel, measure thalweg depth (cm) at each of 101 thalweg transects. To reference location:

- Record the letter code for the lowest major transect referenced (e.g. A).
- Record depth and occurrence data into the appropriate thalweg transect row (e.g. .0)

These thalweg stations are located 0.2 bankfull widths apart from each other; bankfull width is based on an estimate made during the site layout.

While measuring thalweg depth, also evaluate whether each of these features is present at each thalweg transect:

- bar
- edge pool

Circle “Y” for “yes” and “N” for “no”.

References

Armantrout, N. B., Compiler. 1998. Glossary of Aquatic Habitat Inventory Terminology. American Fisheries Society, Bethesda, Maryland.

Endreny, T.A. 2009. *Fluvial Geomorphology Modules*, State University of New York College of Environmental Science and Forestry, National Oceanic and Atmospheric Administration, and the University Corporation for Atmospheric Research. www.fgmorph.com

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Appendix O

Large Woody Debris Tally for Waded Streams of Western Washington

Purpose and Scope

This method explains how to count pieces of large woody debris in waded streams for the Status and Trends Program when traversing the length of the stream site. Observations are limited to the main channel. This method applies to streams of Western Washington (west of the Cascade ridge), where natural conditions are expected to include larger sizes of wood.

Definitions

Definitions of acronyms and other terms are found in Table O-1.

Table O-1. Definitions.

Term or Acronym	Definition
DCE	Data Collection Event. Data are indexed using this code which includes the SITE_ID, the date, and the time that the event began. It uses this format: **WAM06600-NNNNNN-dce-20YY-MMDD-HHMM** **NNNNNN** = the number portion of the SITE_ID. **YY** = the last two numeric digits of the year that the event occurred. **MM** = the two numeric digits for the month that the event occurred. **DD** = the two numeric digits for the day within the month that the event occurred. **HHMM** = the military time when the event began.
LWD	Large woody debris. This is dead wood that is at least 10 cm diameter and more than 2 m long.
Main channel	Channels in a stream are divided by islands (dry ground that rises above bankfull stage). The main channel contains the greatest proportion of flow. For this method it is called channel number 0.
major transect	One of 11 equidistant transects across the length of a site. These are labeled as follows: A0 (lowest), B0,C0,….K0 (highest)
Side channels	Channels in a stream are divided by islands (dry ground that rises above bankfull stage). Side channels are those that contain less flow than the main channel. These are identified and enumerated (1,2,3 etc.) as encountered during the DCE.
thalweg transect	One of 101 equidistant transects across the length of a site. Labeling includes the name of the major transect. For example the thalweg transects between (and including) major transects A and B would be labeled as follows: A0, A1, A2, A3, A4, A5, A6, A7, A8, A9, B0 (i.e.., thalweg transect A0 is identical to major transect A)

Personnel Responsibilities

This method is performed by 1 person. This method is applied at every DCE. Observations are made while walking upstream in the main channel. Staff performing this method must have been trained.

Equipment, Reagents, Supplies

- No. 2 pencil
- *Thalweg Data Form*
- Measuring rod
- Calipers

Summary of Procedure

This procedure is derived from Peck et al (2006) and Moberg (2007).

One person, while walking upstream, counts the number of pieces of large woody debris (LWD), that are (at least partially) within the bankfull channel of each stream segment (e.g. A0 to B0) in the main channel. Pieces are tallied according to 12 size classes (4 diameter classes for each of 3 length classes).

Size Classes

Diameter:

- Diameter 1: 10 to 30 cm
- Diameter 2: > 30 to 60 cm
- Diameter 3: > 60 to 80 cm
- Diameter 4: > 80 cm

Length:

- Length 1: 2 to 5 m
- Length 2: > 5 to 15 m
- Length 3: > 15 m

Considering taper

Wood pieces have a taper. Considerations for taper are illustrated in Figure O-1. The diameter of a log is based on the thickest end. The length of a log only counts the portion that has a diameter of more than 10 cm.

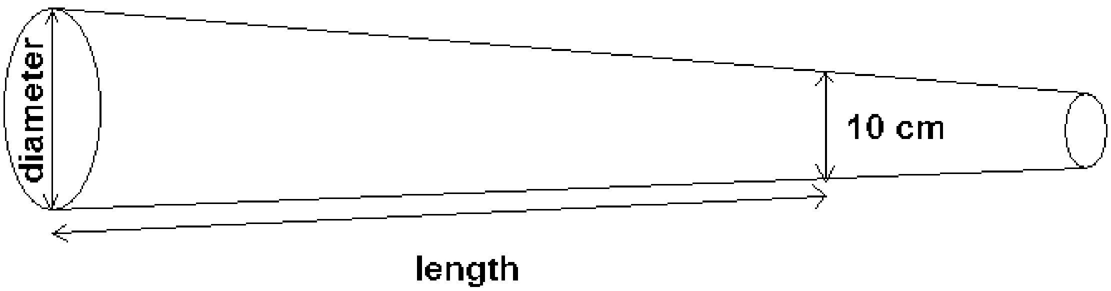


Figure O-1. Diagram of how to estimate the dimensions of a log.

Record

Refer to the *Thalweg Data Form* (Figure O-2). Identify and tally LWD pieces that lie in the bankfull channel. After tallying, sum the marks separately for each size class and enter the number into the corresponding box for each class.

LWD Count	Example: ~~IIII~~ I 6				Check box if all are zero ☐		
	2-5 m		5-15 m		>15 m		Flag
10-30 cm	III	3	~~IIII~~	5	II	2	
30-60 cm	I	1	III	3	/	1	
60-80 cm		0		0		0	
>80 cm		0		0		0	
LWD Notes:							

Figure O-2. A portion of the *Thalweg Data Form*, with example data

References

Moberg, J. 2007. A field manual for the habitat protocols of the Upper Columbia Monitoring Strategy. Prepared for and funded by Bonneville Power Administration's Integrated Status and Effectiveness Monitoring Program. Terraqua, Inc. Wauconda, WA
http://www.nwfsc.noaa.gov/research/divisions/cbd/mathbio/isemp/docs/isemphabitatprotocolsfieldmanualdraft070615.pdf

Peck, D.V., Herlihy, A.T., Hill, B.H., Hughes, R.M., Kaufmann, P.R., Klemm, D.J., Lazorchak, J.M., McCormick, F.H., Peterson, S.A., Ringold, P.L., Magee, T., and Cappaert, M.R. 2006. Environmental Monitoring and Assessment Program-Surface Waters, Western Pilot Study, Field Operations Manual for Wadeable Streams. EPA/620/R-06/003. U.S. Environmental Protection Agency, Washington, D.C.
http://www.epa.gov/wed/pages/publications/authored/EPA620R-06003EMAPSWFieldOperationsManualPeck.pdf

Appendix P

Habitat Unit Descriptions Along the Main Channel Thalweg

Purpose and Scope

This method explains how to identify and count habitat units for the Status and Trends Program when traversing the length of the stream site. The habitat unit descriptions are based on the Hawkins *et al*. (1993) classification system (Figure P-1). Observations in this method will be restricted to the main channel.

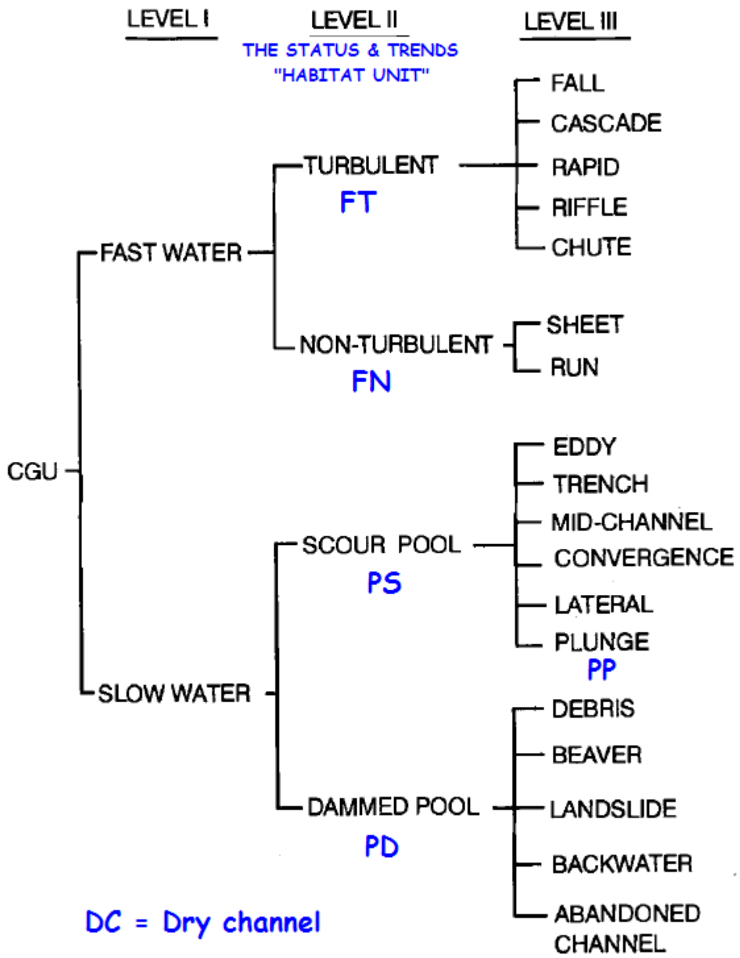


Figure P-1. Categories of channel geomorphic units (CGU) described by Hawkins *et al* (1993) and their three levels of resolution. This figure is modified from Hawkins *et al* (1993), with Status and Trends habitat unit codes displayed in blue text.

Definitions

Definitions of acronyms and other terms are found in Table P-1.

Table P-1. Definitions.

Term or Acronym	Definition
Bankfull stage	This stage is delineated by the elevation point of incipient flooding, indicated by deposits of sand or silt at the active scour mark, break in stream bank slope, perennial vegetation limit, rock discoloration, and root hair exposure (Endreny 2009).
Bankfull width	Horizontal distance between the bankfull stage on the left bank and the bankfull stage on the right bank. For Status and Trends, this is measured in tenth of meters.
Dammed pool	A pool formed by impounded water from complete or nearly complete channel blockage (Armantrout, 1998)
DCE	Data Collection Event. Data are indexed using this code which includes the SITE_ID, the date, and the time that the event began. It uses this format: **WAM06600-NNNNNN-dce-20YY-MMDD-HHMM** **NNNNNN** = the number portion of the SITE_ID. **YY** = the last two numeric digits of the year that the event occurred. **MM** = the two numeric digits for the month that the event occurred. **DD** = the two numeric digits for the day within the month that the event occurred. **HHMM** = the military time when the event began.
Dry channel	A habitat unit is designated as dry channel (DC) where flow is subsurface.
Fast non-turbulent	Habitat unit with smooth, laminar flow that is less deep than in pools. Examples include a sheet or run.
Fast turbulent	Habitat unit with supercritical flow, with hydraulic jumps sufficient to entrain air bubbles and create whitewater (Armantrout, 1998). Examples include water-falls, cascades, rapids, and riffles.
Habitat Unit	Habitat units are “quasi-discrete areas of relatively homogeneous depth and flow that are bounded by sharp physical gradients… Different types of units are usually in close enough proximity to one another that mobile stream organisms can select the type of unit that provides the most suitable habitat” (Hawkins et al. 1993). For Status and Trends, any unit (with two exceptions) must be at least **as long as *half* their wetted width** and they must include the thalweg. Plunge pools and dry channels are the exceptions. Plunge pools can be shorter than half their width. Dry channels have no wetted width and only need to extend 20% of a site’s bankfull width (1/100th of the entire stream site’s length).
Left bank	A person facing downstream will have the left bank on their left side.
Main channel	Channels in a stream are divided by islands (dry ground that rises above bankfull stage). Main channels contain the greatest proportion of flow.

	For this method it is called channel number 0.
major transect	A subset of the thalweg transects. Each of 11 equidistant transects across the length of a site. These are labeled as follows: A0 (lowest), B0, C0….K0 (highest).
minor transect	A subset of the thalweg transects. Each of 10 equidistant transects across the length of a site. These are situated mid-way between major transects and are labeled as follows: A5, B5, C5….K5.
Plunge pool	A pool created by water that passes over an obstruction and drops steeply to scour a basin in the streambed below (Armantrout 1998). This plunge type of scour pool is coded separately because its length criteria are different. Plunge pools can be shorter than half the wetted width.
Pool	For Status and Trends, this is a habitat unit that has a maximum depth at least 1.5 times its crest depth.
Pool crest depth (scour pools)	Thalweg depth at the shallowest tail-out (downstream) end of the pool.
Pool crest depth (dammed pools)	Thalweg depth at the shallowest upstream end of the pool.
Pool maximum depth	Deepest thalweg depth in a pool habitat unit.
Right bank	A person facing downstream will have the right bank on their right side.
Scour pool	Pool created by the scouring action of current flowing against an obstruction (Armantrout 1998). Examples include eddy pools, trench pools, mid-channel pools, convergence pools, and lateral scour pools.
Side channels	Channels that contain less flow than the main channels. These are identified and enumerated (1,2,3 etc.) as encountered (see the method for thalweg measurements) during the DCE.
Thalweg	Path of a stream that follows the deepest part of the channel (Armantrout, 1998).
Thalweg depth	Water depth along the path of the thalweg.
thalweg transect	The stream site is conceptually divided longitudinally into 100 segments, separated by 101 thalweg transects. Thalweg transects are separated by 0.2 (site average) bankfull widths from each other. The thalweg transects are labeled from the bottom of the site to the top as follows: A0, A1, A2, A3, A4, A5, A6, A7, A8, A9, B0…K0.

Personnel Responsibilities

This method is performed by 1 person and who dictates data to a second person who records. This method is applied at every DCE. Observations are made while walking upstream in the thalweg of the main channel. Staff performing this method must have been trained.

Equipment, Reagents, Supplies

- No. 2 pencil
- *Thalweg Data Form*
- Measuring rod
- 50-m tape or laser rangefinder

Summary of Procedure

This procedure is derived from Moberg (2007).

Refer to the *Thalweg Data Form* (Figures P-1 and P-2). Identify and code habitat units consecutively during the walk upstream. A separate Thalweg Data Form is recorded for sets of observations that span between major transects. Data will include:

- type code,
- unit identity (number),
- pool forming code, and
- depths (for pools).

Habitat Unit Number	Habitat Unit Type FT, FN, PS, PD, PP, DC	Pool Forming Code (N, W, R, B, F) Code 1	Code 2	HU Width (m.x)	Max Pool Depth (cm)	Crest Pool Depth (cm)	Channel Unit Notes:
1	PD	W	B	3.5	90	30	Pool formed by both boulder & wood
2	PP	W		4.2	75	15	
3	FN	N		4.8			

Figure P-1. A portion of the *Thalweg Data Form*, with example data for habitat unit type, pool forming code, habitat unit width, and pool depths.

Transect A	Thalweg Depth (cm)	Bar? (circle)	Edge Pool? (circle)	Habitat Unit Number
.0		Y N	Y N	1
.1		Y N	Y N	1
.2		Y N	Y N	1
.3		Y N	Y N	1
.4		Y N	Y N	2
.5		Y N	Y N	2
.6		Y N	Y N	3
.7		Y N	Y N	3
.8		Y N	Y N	3
.9		Y N	Y N	3

Figure P-2. A portion of the Thalweg Data Form, with example data for habitat unit locations relative to thalweg transects.

Type Code

With each step up the thalweg, evaluate the wetted channel for conformity to the Hawkins *et al* (1993) classification system (Figure U-1). We are focusing on Level II designations. The main division is between slow water (pools) and fast water (e.g., cascades, riffles, or runs). All habitat units (except plunge pools or dry channels) must be at least as long as half the wetted width. All pools have specific depth criteria (Table U-1): the maximum depth must be at least 1.5 times the depth at the pool crest. Record the unit type code (Table U-2) on the *Thalweg Data Form* (Figure U-2).

Table P-2. Habitat unit type codes.

Unit Type	Description
FT	Fast Turbulent (riffle, cascade, waterfall)
FN	Fast Non-Turbulent (sheet, run)
PS	Scour pool
PD	Dammed pool
PP	Plunge pool
DC	Dry channel

Unit Number

After you designate the habitat unit type (Table P-3), assign a habitat unit number. These are consecutive number counts for the whole stream site. For each form, record data for any new habitat units that appear since the last encountered major transect. For example, if habitat units numbered 1, 2, and 3 were recorded between major transects A and B, then new units encountered between B and C would begin with habitat unit number 4.

Pool Forming Code

On the *Thalweg Data Form* (Figure P-2), record the pool forming code (Table P-3) to describe the obstruction that led to pool formation. Assign "N" for habitat units other than pools. If pool formation could be associated with two types (e.g boulder *and* large wood), use both columns on the form, with one code per column.

Table P-3. Pool forming codes.

Pool Forming Code	Description
N	Not a pool
W	Large Woody Debris
R	Rootwad
B	Boulder/Bedrock
F	Fluvial (non-specific stream process)

Habitat Unit Width

Estimate the average wetted width (nearest tenth of a meter) of the habitat unit for the full course of its length. Record this value on the *Thalweg Data Form* (Figure P-2) A measurement is not required. Just consider the relative width compared to the width measurements performed at nearby major transects and minor transects.

Pool Depths

With a measuring rod, measure water depth (cm) in each of two locations in the thalweg of pools:

- at the crest
- at maximum depth.

Crest depth is measured differently, depending upon the pool type. For scour pools and plunge pools, the crest depth is measured where water exits the pool. For dammed pools, the crest depth is measured where water enters the pool.

Record crest depth and maximum depth on the *Thalweg Data Form* (Figure P-2). No data need to be recorded for non-pool habitat units.

Position

After identifying and describing habitat units (Figure P-1), record the position of each habitat unit relative to thalweg stations (Figure P-2).

References

Armantrout, N.B., compiler. 1998. Glossary of aquatic habitat inventory terminology. American Fisheries Society, Bethesda, Maryland.

Endreny, T.A. 2009. *Fluvial Geomorphology Modules*, State University of New York College of Environmental Science and Forestry, National Oceanic and Atmospheric Administration, and the University Corporation for Atmospheric Research. www.fgmorph.com

Hawkins, C.P., JL. Kershner, P.A. Bisson, M.D. Bryant, L.M. Decker, S.V. Gregory, D.A. McCullough, C.K. Overton, G.H. Reeves, R.J. Steedman, and M.K. Young. 1993. Hierarchical approach to classifying stream habitat features. Fisheries 18:3-12.

Moberg, J. 2007. A field manual for the habitat protocols of the Upper Columbia Monitoring Strategy. Prepared for and funded by Bonneville Power Administration's Integrated Status and Effectiveness Monitoring Program. Terraqua, Inc. Wauconda, WA http://www.nwfsc.noaa.gov/research/divisions/cbd/mathbio/isemp/docs/isemphabitatprotocolsfieldmanualdraft070615.pdf

Appendix Q

Side-Channel Descriptions

Purpose and Scope

This method explains how to identify and count side-channels of waded streams for the Status and Trends Program when traversing the length of the stream site. Observations are limited to portions of side channels that occur next to the sampled part of the main channel (above Transect A0 and below Transect K0).

Definitions

Definitions of acronyms and other terms are found in Table Q-1.

Table Q-1. Definitions.

Term or Acronym	Definition
DCE	Data Collection Event. Data are indexed using this code which includes the SITE_ID, the date, and the time that the event began. It uses this format: **WAM06600-NNNNNN-dce-20YY-MMDD-HHMM** **NNNNNN** = the number portion of the SITE_ID. **YY** = the last two numeric digits of the year that the event occurred. **MM** = the two numeric digits for the month that the event occurred. **DD** = the two numeric digits for the day within the month that the event occurred. **HHMM** = the military time when the event began.
Main channel	Channels in a stream are divided by islands (dry ground that rises above bankfull stage). The main channel contains the greatest proportion of flow. For this method it is called channel number 0.
major transect	One of 11 equidistant transects across the length of a site. These are labeled as follows: A0 (lowest), B0,C0,….K0 (highest)
Side channels	Channels in a stream are divided by islands (dry ground that rises above bankfull stage). Side channels are those that contain less flow than the main channel. These are identified and enumerated (1,2,3 etc.) as encountered during the DCE.
thalweg transect	One of 101 equidistant transects across the length of a site. Labeling includes the name of the major transect. For example the thalweg

	transects between (and including) major transects A and B would be labeled as follows: A0, A1, A2, A3, A4, A5, A6, A7, A8, A9, B0 (i.e.., thalweg transect A0 is identical to major transect A)

Personnel Responsibilities

This method is performed by 1 person who dictates to another. This method is applied at every DCE. Observations are made while walking upstream to measure thalweg depths of the main channel. Staff performing this method must have been trained.

Equipment, Reagents, Supplies

- No. 2 pencil
- *Thalweg Data Form*
- Measuring rod
- Field notebook

Summary of Procedure

This procedure is derived from Moberg (2007).

Refer to the *Thalweg Data Form* (Figures S-1 and S-2). Identify and count side channels occurring within the length of the sample site. Estimate their widths.

Identify and count

Identify and code side channels consecutively for the entire streams site. Number them as encountered while walking upstream. Note their presence for each of the 101 Thalweg Transects of the stream site. This will require 11 *Thalweg Data Forms* to complete (A-K).

Transect A	Thalweg Depth (cm)	Bar? (circle)	Edge Pool? (circle)	Habitat Unit Number	Side Channel Numbers				
.0		Y N	Y N						
.1		Y N	Y N		1				
.2		Y N	Y N		1				
.3		Y N	Y N		1				
.4		Y N	Y N		1	2			
.5		Y N	Y N		1	2			
.6		Y N	Y N		1	2			
.7		Y N	Y N		1	2			
.8		Y N	Y N		1	2	3		
.9		Y N	Y N		1	2	3		

Figure Q-1. A portion of the *Thalweg Data Form*, with example data showing the presence or absence of side-channels at each Thalweg Transect.

Estimate Width

For each channel, estimate wetted width (nearest tenth of a meter). Make at least one representative measurement (in a notebook) between each major transect then visually estimate an average value for the length of the side-channel. Record this channel average on the *Thalweg Data Form* (Figure Q-2). In your width estimate, do *not* include portions of the channel that occur below transect A0 or above transect K0.

Side Channel Number	Width (m.x)	Side Channel Notes:
1	1.0	left side of main channel
2	2.3	diverts from channel 1, not from main channel
3	3.7	Right side of main channel

Figure Q-2. A portion of the *Thalweg Data Form*, with example data for channel width estimates.

References

Moberg, J. 2007. A field manual for the habitat protocols of the Upper Columbia Monitoring Strategy. Prepared for and funded by Bonneville Power Administration's Integrated Status and Effectiveness Monitoring Program. Terraqua, Inc. Wauconda, WA http://www.nwfsc.noaa.gov/research/divisions/cbd/mathbio/isemp/docs/isemphabitatprotocolsfieldmanualdraft070615.pdf

Appendix R

Width and Substrate Measurements at Minor Transects in Waded Streams

Purpose and Scope

This method explains how to measure width and substrate characteristics for the Status and Trends Program at each of 10 equidistant transects at each site. Measurements in this procedure will be restricted to one main channel. This method is performed in conjunction with the method for measuring thalweg depth.

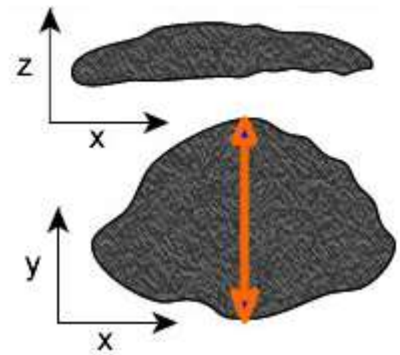
Instruments included on the procedure include distance measuring devices (e.g., measuring rod, or 50-m measuring tape, caliper), and a10-cm ring.

Definitions

Definitions of acronyms and other terms are found in Table R-1.

Table R-1. Definitions.

Term or Acronym	Definition
bankfull depth	This is the vertical distance between the channel bed surface and the mean height of bankfull stage.
bankfull height	Vertical distance between surface of water and bankfull stage. For Status and Trends, this is measured in centimeters. It is measured at the left and right wetted margins of each major transect and a mean value is computed for each channel at that transect.
bankfull stage	This stage is delineated by the elevation point of incipient flooding, indicated by deposits of sand or silt at the active scour mark, break in stream bank slope, perennial vegetation limit, rock discoloration, and root hair exposure (Endreny 2009).
bankfull width	Horizontal distance between the bankfull stage on the left bank and the bankfull stage on the right bank. For Status and Trends, this is measured in tenth of meters.
intermediate axis	The diameter of a particle that is neither the longest nor the shortest of mutually perpendicular axes (Bain 1999, Harrelson et al 1994). See below for a diagram from Endreny (2009):

	
left bank	A person facing downstream will have the left bank on their left side.
main channel	Channels in a stream are divided by islands (dry ground that rises above bankfull stage). Main channels contain the greatest proportion of flow.
major transect	A thalweg transect that is labeled with a “0” The 11 are: A0, B0, C0, D0, E0, F0, G0, H0, I0, J0, K0
minor transect	A thalweg transect that is labeled with a “5” The 10 are A5, B5, C5, D5, E5, F5, G5, H5, I5, J5 Minor transects are located mid-way between major transects.
right bank	A person facing downstream will have the right bank on their right side.
side channels	Channels that contain less flow than the main channels. These are identified and enumerated (1,2,3 etc.) as encountered (see the method for thalweg measurements) during the data collection event.
site	A site is defined by the coordinates provided to a sampling crew and the boundaries established by the site layout method. Typically, the site extends 10 bankfull widths downstream from the coordinates and 10 bankfull widths upstream. The site also includes all riparian plots examined during the *Data Collection Event*. The site consists of many stations at which measurements or samples are collected.
station	Any location within the site where an observation is made or part of a sample is collected.
transect	A line of study that crosses the direction of flow, divided into intervals where observations are collected.
thalweg transect	There are 101 thalweg transects on the site, each located 0.2 bankfull widths apart from each other. They are labeled as follows: A0, A1, A2, A3, A4, A5, A6, A7, A8, A9, B0…K0. The lowest is A0. The highest is K0.
wetted width	Farthest horizontal distance between water edge on the left and right sides of a channel.

Personnel Responsibilities

This method is performed by 2 persons: an observer and a recorder. This method is applied at each minor transect. It is performed in conjunction with the method for measuring thalweg depth. Staff performing this method must have been trained.

Equipment, Reagents, Supplies

- No. 2 pencil
- measuring rod
- 50-m tape
- calculator
- 10-cm ring

Summary of Procedure

Measure the channel width and then make observations about substrate size at 11 equidistant stations across the minor transect.

Widths

At each minor transect, measure distance (tenth of meters) for:

- bankfull width
- wetted width
- total bar width (sum for all bars)

Record these widths on the Thalweg Data Form (Figure R-1).

Wet Width (m.x)	BF Width (m.x)	Bar Width (m.x)
4.2	5.3	0.3

Figure R-1. Part of the *Thalweg Data Form*,
with example data for widths at the minor transect.

Station Location

Identify the ***Transect Station LeftRight***. Example stations for minor transect A5 would be:

12. **A500** – at the left bankfull stage
13. **A501** – 10% distance across the channel
14. **A502** – 20% distance across the channel
15. **A503** – 30% distance across the channel
16. **A504** – 40% distance across the channel
17. **A505** – half way across the channel
18. **A506** – 60% distance across the channel
19. **A507** – 70% distance across the channel
20. **A508** – 80% distance across the channel
21. **A509** – 90% distance across the channel
22. **A510** – at the right bankfull stage

Substrate Type

Hold the measuring rod vertically and rest it on the substrate at each station. Estimate the substrate particle type at the front of the measuring rod, where it rests on the surface of the streambed. Estimate the size class of that particle based on the intermediate axis length. Record the ***substrate type code*** (Table R-1) on the Thalweg Data Form (Figure R-2) for each station. For coarse gravel and cobble, use calipers to measure the intermediate axis length of the particle and confirm your estimate of size. For larger sizes, use the measuring rod to confirm your estimate.

Particles smaller than 100 mm are evaluated using a 10 cm ring surrounding the sample point. All particles within the ring are evaluated for size and embeddedness, not just the point. Record the estimated average for surface substrate within the ring.

	LB	01	02	03	04	05	06	07	08	09	RB	Substrate Notes:
Substrates at 5	SA	GF	GC	CB	CB	XB	XB	XB	XB	XB	FN	Stations 5-9 are one boulder

Figure R-2. Part of the *Thalweg Data Form*, with example data for substrate types along the minor transect.

Table R-1. Substrate codes, types, and sizes.

CODE	TYPE	SIZE RANGE	SIZE GUAGE
RS	Bedrock (smooth)	> 4 m	larger than a car
RR	Bedrock (rough)	> 4 m	larger than a car
RC	Concrete/Asphalt	> 4 m	larger than a car
XB	Large Boulder	1-4 m	meter stick to car
SB	Small boulder	>250 mm – 1 m	basketball to meter stick
CB	Cobble	>64 mm – 250 mm	tennis ball to basketball
GC	Gravel, coarse	>16 mm to 64 mm	marble to tennis ball
GF	Gravel, fine	>2 mm to 16 mm	ladybug to marble
SA	Sand (2-16 mm)	>0.06 mm to 2 mm	gritty to ladybug
FN	Fines (silt/clay/muck)	< 0.06 mm	non gritty
HP	Hardpan - hardened fines	any size	
WD	Wood	any size	
OT	Other (doesn't fit choices above)	any size	

References

Bain, M.B. 1999. Substrate. Pages 95 to 103 *in* M.B. Bain and N.J. Stevenson, editors. Aquatic habitat assessment: common methods. American Fisheries Society, Bethesda, Maryland.

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Appendix S

Measuring Slope and Bearing in Wadeable Streams

Purpose and Scope

This method describes how to measure slope and bearing of the main channel at each site during a data collection event (DCE) for Washington's Status and Trends Program. It applies to waded streams. This method requires use of a hand level, measuring rod, and a compass to make incremental measurements across each of at least 20 segments of the stream site.

Definitions

Definitions of acronyms and other terms are found in Table S-1.

Table S-1. Definitions.

Term or Accronym	Definition
DCE	Data Collection Event. Data are indexed using this code which includes the SITE_ID, the date, and the time that the event began. It uses this format: **WAM06600-NNNNNN-dce-20YY-MMDD-HHMM** **NNNNNN** = the number portion of the SITE_ID. **YY** = the last two numeric digits of the year that the event occurred. **MM** = the two numeric digits for the month that the event occurred. **DD** = the two numeric digits for the day within the month that the event occurred. **HHMM** = the military time when the event began.
Main channel	Channels in a stream are divided by islands (dry ground that rises above bankfull stage). The main channel contains the greatest proportion of flow.
Major transects	Major transects are a subset of the thalweg transects. The length of the stream is divided by 11 equidistant major transects: A0, B0, C0, D0, E0, F0, G0, H0, I0, J0, and K0.

	The bottom of the site is at A0, The top is at K0
Minor transects	Minor transects are a subset of the thalweg transects. There are 10 minor transects that occur midway between major transects. These are labeled A5, B5, C5, D5, E5, F5, G5, H5, I5, and J5.
Segments	The portions of the stream length over which incremental slope and bearing observations are made. There are at least 20 segments in each site, normally equal in size. Sometimes more segments or unequal segments are inserted to account for obscured lines-of-sight or sharp changes in channel direction.
thalweg	Path of a stream that follows the deepest part of the channel (Armantrout, 1998).
Thalweg transects	The stream site is conceptually divided into 101 equally-spaced transects that are perpendicular to the thalweg of the main channel. These are labeled A0, A1, A2, A3, A4, A5, A6, A7, A8, A9, B0, B1, B2, B3….K0 (from bottom to top of the site).

Personnel Responsibilities

Two persons perform this activity: one “rodder” who holds a measuring rod in a vertical position and a “sighter” who sights on the “rodder” with a hand level and compass to record data. Crew members must be trained prior to performing this method.

Equipment, Reagents, Supplies

- Hand level (5x magnification)
- Monopod for hand level
- Measuring rod (telescoping)
- Compass (handheld, magnetic)
- Range finder
- 50-meter tape
- *Slope and Bearing Form*
- Pencil

Summary of Procedure

A two person-crew performs this procedure incrementally, once for each of at least 20 segments of the main channel for the entire site. Segments evaluated are normally between major and minor transects (e.g A5-A0), but intermediate measurements may be used if necessary (e.g. due to thick vegetation or sharp bends in the channel). There should be no space between segments and no overlap of segments.

The crew can either work moving up the stream or down, depending on efficiency of overall work flow. We will describe the technique for working from the top of the stream, downward. This method is based on modifications of Peck et al (2006) and Moberg (2007).

Slope

The *sighter* stands at the water's edge of a transect at a higher elevation (Figure S-1). This person will sight downstream toward a measuring rod at a lower transect. Use a monopod to rest the hand level at a fixed eye height. The *rodder* holds the measuring rod vertically, with its base at the surface of the water. The *rodder* can assist by pointing to the numbers on rod and adjusting up or down as directed by the *sighter*.

Record these things on the Slope and bearing Form (Figure S-2):

- Identity of transect where the *sighter* stands
- Identity of transect where the *rodder* stands
- Eye height (cm)
- Level Height (cm)

Note: Sometimes it is easier to sight in the wetted channel rather than the edge, to avoid vegetation. If the monopod or measuring rod rest below the surface of the water, subtract that depth from the eye height or level height.

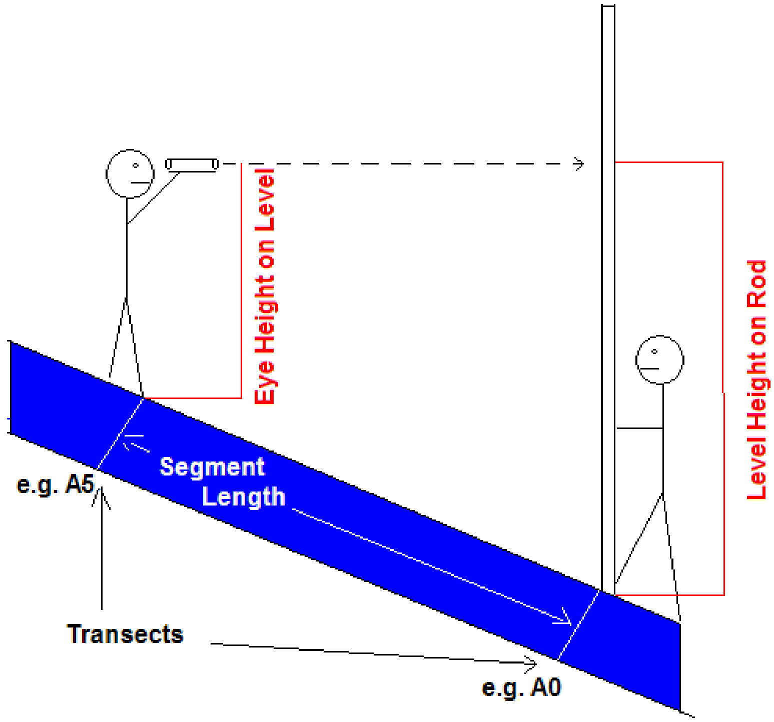

Figure S-1. Crew positions when measuring the slope and bearing for the segment between transects A5 and A0.

Status & Trends - Slope and Bearing Form

DCE: WAM06600-000152-DCE-2009-0715-10:00

Top Transect* LEVEL COMPASS	Bottom Transect* ROD	Segment Length (m.x)	Eye Height on Level (cm)	Level Height on Rod (cm)	Bearing (deg)	Flag	Comment
K0	J5	7.5	150	172	333		Started here
J5	J0	7.5	150	154	326		
J0	I5	7.5	150	154	293		
I5	I0	7.5	150	203	251		
I0	H5	7.5	150	285	262		
H5	H0	7.5	150	163	249		
H0	G5	7.5	150	225	227		
G5	G0	7.5	150	174	226		
G0	F5	7.5	150	173	237		
F5	F0	7.5	150	160	248		
F0	E5	7.5	150	171	259		
E5	E0	7.5	150	166	276		
E0	D5	7.5	150	230	310		
D5	D0	7.5	150	172	289		
D0	C5	7.5	150	188	301		
C5	C0	7.5	150	166	263		
C0	B5	7.5	150	172	237		
B5	B0	7.5	150	173	234		
B0	A5	7.5	150	166	262		
A5	A0	7.5	150	171	242		

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*Normally sight between major and minor transects: K0 to J5, J5 to J0, J0 to I5, etc. unless there is a need for intermediate measurements. For intermediate measurements, always sight to/from a transect station 0-9 (for example K0 to J7 and J7 to J5). Bearings are magnetic north facing downstream (not adjusted).

Figure S-2. The Slope and Bearing Form, with example data.

Bearing

The *sighter* stands at a transect at a higher elevation (Figure S-1). This person will sight downstream toward the *rodder* at a lower transect. The *sighter* will then point the compass toward the *rodder* and parallel to the thalweg. On the Slope and Bearing Form, record the bearing (magnetic north) of the thalweg between the top and bottom of the segment.

NOTE: If sighting from bottom to top, record the bearing south.

References

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Appendix T

Sampling the Vertebrate Assemblage in Wadeable Streams

Purpose and Scope

This method describes how to use a backpack electrofisher to detect the presence and relative abundance of aquatic vertebrate species at each site for Washington's Status and Trends Program. It applies to waded streams. This method requires measurement of the associated physical and chemical environmental variables described in other methods within this protocol.

Definitions

Definitions of acronyms and other terms are found in Table T-1.

Table T-1. Definitions.

Term or Accronym	**Definition**
Ambient conductivity	Conductivity (µS/cm) of the water for the ambient water temperature. Electrofishing success depends on *ambient* conductivity rather than specific conductivity. It can be estimated from specific conductivity with this formula from Reynolds (1996): $C_a = C_s/[1.02^{(Ts\text{-}Ta)}]$ Ambient conductivity is *the* most important habitat factor affecting electrofishing efficiency.
DCE	Data Collection Event. Data are indexed using this code which includes the SITE_ID, the date, and the time that the event began. It uses this format: **WAM06600-NNNNNN-dce-20YY-MMDD-HHMM** **NNNNNN** = the number portion of the SITE_ID. **YY** = the last two numeric digits of the year that the event occurred. **MM** = the two numeric digits for the month that the event occurred. **DD** = the two numeric digits for the day within the month that the event occurred. **HHMM** = the military time when the event began.
DNA	Deoxyribonucleic acid (DNA) is a long molecule in organisms that carries

	trait information including species identity.
Duty Cycle	Duty cycle is the percentage of time that the output pulse is “on” during the time period between pulse cycles. On the Smith-Root LR-20 electrofisher, the duty cycle switch is located on the upper left center of the control panel. Increasing duty cycle might increase stress to fish.
FPARS	FPARS is the Forest Practices Application and Review System (WDNR, 2009). They use detection sampling and habitat modeling to assign stream type codes. The codes describe whether fish are expected to use each stream.
Frequency	This describes the pulse rate per second. On the Smith-Root LR-20 electrofisher, the frequency switch is located on upper left of the front panel. Most pulsed DC electrofishing is done at 30-60 Hz. Increasing voltage increases the rate of fish injuries.
galvanotaxis	This is electrically-**induced movement** (usually toward the anode, but sometimes toward the cathode too). When pulsed DC current is supplied to water, fish are electrically induced to swim toward the electrode. This is called galvanotaxis.
Habitat unit	Habitat units are “quasi-discrete areas of relatively homogeneous depth and flow that are bounded by sharp physical gradients… Different types of units are usually in close enough proximity to one another that mobile stream organisms can select the type of unit that provides the most suitable habitat” (Hawkins et al. 1993). For Status and Trends, any unit (with two exceptions) must be at least **as long as *half* their wetted width** and they must include the thalweg. Plunge pools and dry channels are the exceptions. Plunge pools can be shorter than half their width. Dry channels have no wetted width and only need to extend 20% of a site’s bankfull width (1/100th of the entire stream site’s length).
ITIS_SN	Taxonomic serial number provided by ITIS (2009)
Major transects	The length of the stream is divided by 11 equidistant major transects: A0 (bottom) to K0 (top).
narcosis	A state of electrically-induced **immobility with slack muscles**. As fish are induced into galvanotaxis and approach the anode, their reaction changes to narcosis (muscle relaxation and loss of equilibrium). While under narcosis, the fish may continue to swim, upside down, toward the anode. Narcosis can sometimes be achieved near the cathode too (Reynolds, 1996).
Power	This is the energy delivery rate. Electrofishing can be viewed as a power-based phenomena. Electrofishing effectiveness is based on how much power is transferred to the fish. Power transfer is most efficient when water conductivity closely matches the conductivity of fish flesh (near 100 µS/cm for most species).
Segment	Wetted stream area that is defined between major transects. There are 10 segments in each site. For example segment A is the portion of the stream site that is situated between major transects A0 and B0.

species-life stage	The age status for each species captured: juvenile or adult. Habitat requirements and characteristics can change for species as their status changes from juvenile to adult. Some undergo transformation from a larval stage (e.g. lamprey and frogs). Others may just generally get larger.
Specific conductivity	Electrical conductivity is a measure of water's ability to conduct electricity, and therefore a measure of ionic activity and content. It is the reciprocal of specific resistivity. Specific conductivity is conductivity adjusted to 25˚ C (reported in µS/cm at 25˚ C). This is what most field conductivity meters report.
tetany	A state of electrically-induced **immobility with rigid muscles**. Tetany is usually achieved near the anode, but sometimes near the cathode. Fish captured before they reach tetany experience a lower risk of injury.
thalweg	Path of a stream that follows the deepest part of the channel (Armantrout, 1998).
Voltage	Voltage is the electrical force, or "pressure", that causes current to flow in a circuit. It is measured in VOLTS (V). As ambient conductivity of water decreases below (approximately) 100 µS/cm, the output voltage must be increased to elicit a response from fish. On the Smith-Root LR-20 electrofisher, the voltage range switch is located on the left side of the front panel. Increasing voltage increases the rate of fish injuries.

Personnel Responsibilities

Three persons perform this activity: an electrofisher operator, a dip netter, and third person who monitors and processes the animals collected. The netter should always be limited to 1 person for consistency.

Field supervisors and crew members must be trained prior to electrofishing. For fishing in waters containing listed salmon or steelhead, the federal government (NOAA, 2000) has special requirements for field supervisors and crew members.

Equipment, Reagents, Supplies

- Backpack electrofisher unit (e.g. Smith-Root LR-20)
- Anode with ring (with as large a diameter bore as possible)
- Cathode (rat-tail)
- Battery (fully charged)
- Electrically insulated gloves
- Electrically insulated waders and wading shoes
- Polarized sun glasses
- Caps with visor
- Measuring Board
- Taxonomic Keys
- Buckets or live wells
- Camera
- Dipnet (1/8” mesh)
- Aquarium net
- Wading shoes (clean)
- Calipers
- Loop or magnifying glass
- Small Cooler with ice, zip-sealing bag, and tag (voucher sample).
- A couple of 500-1000 ml jars with ethanol (lab. checks)
- Abrasive cloth for electrode maintenance

Summary of Procedure

To preserve sample integrity, vertebrate sampling is conducted after sampling for chemistry and invertebrates. The crew first prepares their fishing equipment to best suit the stream conditions and minimize fish injuries. They then walk up through the stream site to perform a single-pass electrofishing sample. Peck et al (2006) and AREMP (2006) served as a basis for much of this method.

Pre-sampling Preparations

Carefully read the sampling permits and NOAA (2000) guidance to determine special requirements. The Scientific Collection Permit from the Washington State Department of Fish and Wildlife is likely to stipulate persons to be contacted prior to each sampling event (e.g. regional biologists). It is also likely to include restrictions from sampling in warm water.

The crew members should each be trained in both electrofishing roles. Practice sessions should be performed prior to sampling, at a location external to the range of threatened or endangered species.

Absence of spawning fish

Prior to sampling verify that there are no salmonids present in spawning condition. Pre-season research on the timing of runs can help. During the site layout the crew should also perform a visual confirmation.

Electrofisher Log

Complete an electrofisher log (e.g. Figure T-1) to determine that the instrument settings will maximize capture efficiency and minimize harm to aquatic vertebrates. The electrofisher log will also help to keep track of settings that work well for each type of stream. Try low intensity settings to start (see Figure T-1), and increase intensity as needed to find a response. Try to stay below 60 Hz, 35% duty cycle and 600 V settings, although at times these might be required. The United States Department of Interior (Brenkman and Connelly, 2008; Connelly and Brenkman, 2008) uses settings of 60 Hz and 400–600 v where this is necessary to find an effective response in National Parks of the Northwest.

ELECTROFISHER LOG FOR LR-20

LR-20 SN:	Site Depth (cm)	Stream:
AnodeE No.	Site Wet Width (m)	WAM06600-__ __ __ __ __ __
Cathode No.	Dom. substrate: ORGANIC ROCKY (circle one)	Date ___ ___ / ___ ___ / 2009

TRIAL	FREQ (HZ)	Duty Cycle (%)	Voltage (V)	RESPONSE OF FISH	Specific Cond SC uS/cm at 25 C	Water Temp ? C	D	Ambient Cond SC ÷ D uS/cm
1						4	1.52	
2						5	1.49	
3						6	1.46	
4						7	1.43	
5						8	1.40	
6						9	1.37	
7						10	1.35	
8						11	1.32	
9						12	1.29	
10						13	1.27	
11						14	1.24	
12						15	1.22	
13						16	1.20	
14						17	1.17	
15						18	1.15	
16						19	1.13	
17						20	1.10	
18						21	1.08	
19						22	1.06	
20						23	1.04	
	15 Hz	10%	50 V	Start testing here (if no info. available)		24	1.02	
	35 Hz	20%	300 V	example for low conductivity water		25	1.00	
	30 Hz	15%	250 V	example for high conductivity water	notes			
	60 Hz	35%	600 V	Try to stay below these				

Figure T-1. The electrofisher log for tracking optimal settings.

Header information

Record the identity of the electrofisher (serial number). Also record the identity of electrodes that you are using (to track malfunctions). Record the site and date. Note the depth, width and substrate of the stream.

Water temperature

Prior to electrofishing, measure and record water temperature (˚C). Check permit restrictions to see if fishing can proceed.

Ambient conductivity

Prior to electrofishing, measure specific conductivity (i.e., the value recorded in $\mu S \cdot cm^{-1}$ at 25˚ C during *in situ* chemistry sampling). Record this on the electrofisher log, to the left of the value for the observed water temperature. Convert this into an estimated ambient conductivity value ($\mu S \cdot cm^{-}$), by dividing the specific conductivity by the "denominator" (D) value in the column to the right of water temperature.

Testing

Test the operation of the electrofisher while situated well downstream from the bottom of the sample site (Transect A0). Evaluate settings to ensure that the audio and light signals are emitting at a standard pace. Also check to see that fish are attracted to the anode with the least possible application of electrical intensity. When ambient conductivity is approximately 100 $\mu S \cdot cm^{-1}$ (about the same as fish flesh), little power is required to effectively fish. For lower conductivity water, higher voltage will be needed. For higher conductivity water, more current will be needed. Details on set-up and testing can be found in Smith-Root (2007).

If captured fish demonstrate signs of injury, lower the settings.

Vertebrate Assemblage Sampling

The crew wades upstream sampling all available habitats equally, spending no more than about 20 minutes in each segment (or 3.5 hours total). One person operates the electrofisher while another nets the vertebrates. A third person processes the fish and records data onto the Vertebrate Collection Form (Figure T-2).

Crew Number (e.g. 1, 2, 3): ______ Reviewed by (Initials): ______

Vertebrate Collection Form - Streams/Rivers

Site Number YY MMDD HH : MM

DCE: W A M 0 6 0 0 - - D C E - 2 0 - - :

FPARS Type ______ FPARS FLAG ______ Fished? ☐ Fished but no verts detected ☐ Fished/Not Fished FLAG ______

On Button Time (sec) ______ Fishing+Processing Time (min) ______ Sample Distance (m) ______

Gear: ☐ Backpack ☐ Raft FLAG for other Sampling Information ______ Water Visibility ☐ Good ☐ Poor Water Temp (c) ______ Cond (cm) ______

Volts: ______
Frequency: ______ Hz
Duty Cycle: ______ %

Notes regarding electrofisher operation:

Jar No.	COMMON NAME	A	J	Tally	Total Count	DNA Count	LENGTH (mm)* Min	Max	Mortality	Flag	SEGMENTS
											O A O C O E O G O I O B O D O F O H O J
											O A O C O E O G O I O B O D O F O H O J
											O A O C O E O G O I O B O D O F O H O J
											O A O C O E O G O I O B O D O F O H O J
											O A O C O E O G O I O B O D O F O H O J
											O A O C O E O G O I O B O D O F O H O J
											O A O C O E O G O I O B O D O F O H O J
											O A O C O E O G O I O B O D O F O H O J
											O A O C O E O G O I O B O D O F O H O J
											O A O C O E O G O I O B O D O F O H O J
											O A O C O E O G O I O B O D O F O H O J
											O A O C O E O G O I O B O D O F O H O J

Flag	Comment

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Page ______ of ______

K = No measurement made, U = Suspect measurement, F1, F2, etc. = flags assigned by each field crew

LENTH* - Enter single fish as minium.

Figure T-2. The Vertebrate Collection Form (front).

Electrofisher Operation

Operate the electrofisher according to manufacturer's instructions (e.g. Smith-Root 2007). At the bottom of the site (transect A0), reset the timer. Tell all staff nearby that you are ready to begin electrofishing. Before you start, they should acknowledge to you that they understand and that they are ready. Then start.

Sampling is complete when reaching the top of a habitat unit that is nearest to transect K0. Tell the data recorder the following information:

- *on-button* time (seconds) in the display
- clock time (minutes) elapsed during sampling
- distance (m) travelled up the length of the stream

Netting

If working in open sunlight, netting must be performed while wearing polarized sun glasses and a brimmed cap. The netter captures vertebrates that move toward the anode. They then place the animals into a bucket (live-well) of fresh stream water. Specimens can be protected from harm by carefully performing these duties:

- Net the fish away from the electrodes
- Do *not* net fish unless your net is empty
- Minimize animals' exposure to air and sunlight
- Pass specimens off for processing quickly
- Do not crowd the live-well
- Keep fresh water in the live well

Processing the Sample

Processing includes data recording. The person processing receives animals from the netter and then completes the Vertebrate Collection Form (Figure T-2). Representative photographs should be taken of each *species-life stage*. After processing, in most cases, live animals are released in quiet water at a location well below samplers. A few select hard-to-identify fish specimens (e.g., lampreys, sculpins, or dace) may be retained for later identification in a laboratory or by a professional taxonomist.

Be sure to examine all animals for electrofishing-induced injuries. If you see them, tell the electrofisher operator to turn down the settings.

Header Information

Begin recording data by completing header information on the Vertebrate Collection Form (Figure T-1). This includes temperature and conductivity data (from the electrofisher log) and your opinion on water visibility (clarity).

When sampling is done, record on-button time (seconds), *fishing+processing* time (minutes), and sample distance (m) along the thalweg.

Count and Presence

1) Identify specimens to species using taxonomic keys, e.g.
    a. Corkran and Thoms (1996)
    b. Jones *et al* (2005)
    c. Leonard *et al* (1993)
    d. Page and Burr (1991)
    e. Pollard *et al* (1997)
    f. Stebbins (2003)
    g. Wydoski and Whitney (2003).
2) Each new life stage (juvenile or adult) per species encountered is assigned a sequential Tag Number. For each tag number, record the designated **common name** (Tables T-1 and T-2). Check "J" for juvenile or "A" for adult.
3) Record a tally mark for each new observation per *species-life stage*. Sum these to complete the "Total Count" column when sampling is complete.
4) Fill in the circle for each segment where a member of a *species-life stage* is observed.
5) Keep track of how many animals die during collection and processing. Record totals in the "Mortality" column of the form.
6) Count the number of animals in each species-life-stage that are retained for later taxonomic analysis. These totals are recorded in the "Voucher Count" column.
7) Make a note (using the flag and comments fields) of any abnormalities observed on animals. This includes deformities, lesions, tumors, fin erosion, or other notable features.

Table T-1. Scientific name, common name, and taxonomic serial number (ITIS, 2009) for fishes that inhabit freshwaters of Washington.

FAMILY	SCIENTIFIC NAME	COMMON NAME	ITIS_SN
Acipenseridae	*Acipenser transmontanus*	WHITE STURGEON	161068
Acipenseridae	*Acipenser medirostris*	GREEN STURGEON	161067
Clupeidae	*Alosa sapidissima*	AMERICAN SHAD	161702
Catostomidae	*Catostomus catostomus*	LONGNOSE SUCKER	163894
Catostomidae	*Catostomus macrocheilus*	LARGESCALE SUCKER	163896
Catostomidae	*Catostomus platyrhynchus*	MOUNTAIN SUCKER	163909
Catostomidae	*Catostomus columbianus*	BRIDGELIP SUCKER	163897
Cobitidae	*Misgurnus anguillicaudatus*	ORIENTAL WEATHERFISH	163978
Cyprinidae	*Mylocheilus caurinus*	PEAMOUTH	163521
Cyprinidae	*Acrocheilus alutaceus*	CHISELMOUTH	163531

Cyprinidae	*Couesius plumbeus*	LAKE CHUB	163535
Cyprinidae	*Rhinichthys umatilla*	UMATILLA DACE	201910
Cyprinidae	*Rhinichthys cataractae*	LONGNOSE DACE	163384
Cyprinidae	*Ptychocheilus oregonensis*	NORTHERN PIKEMINNOW	163523
Cyprinidae	*Gila bicolor*	TUI CHUB	163544
Cyprinidae	*Carassius auratus*	GOLDFISH	163350
Cyprinidae	*Tinca tinca*	TENCH	163348
Cyprinidae	*Notemigonus crysoleucas*	GOLDEN SHINER	163368
Cyprinidae	*Rhinichthys falcatus*	SPECKLED DACE	163387
Cyprinidae	*Cyprinus carpio*	COMMON CARP	163344
Cyprinidae	*Rhinichthys falcatus*	LEOPARD DACE	163386
Cyprinidae	*Richardsonius balteatus*	REDSIDE SHINER	163528
Fundulidae	*Fundulus diaphanus*	BANDED KILLIFISH	165646
Poeciliidae	*Gambusia affinis*	WESTERN MOSQUITOFISH	165878
Esocidae	*Esox lucius x Esox masquinongy*	TIGER MUSKELLUNGE	none
Esocidae	*Esox americanus*	GRASS PICKEREL	162140
Umbridae	*Novumbra hubbsi*	OLYMPIC MUDMINNOW	162161
Gadidae	*Lota lota*	BURBOT	164725
Gasterosteidae	*Gasterosteus aculeatus*	THREESPINE STICKLEBACK	166365
Gasterosteidae	*Culaea inconstans*	BROOK STICKLEBACK	166399
Centrarchidae	*Lepomis cyanellus*	GREEN SUNFISH	168132
Centrarchidae	*Lepomis macrochirus*	BLUEGILL	168141
Centrarchidae	*Lepomis gibbosus*	PUMPKINSEED	168144
Centrarchidae	*Lepomis gulosus*	WARMOUTH	168138
Centrarchidae	*Micropterus dolomieu*	SMALLMOUTH BASS	550562
Centrarchidae	*Micropterus salmoides*	LARGEMOUTH BASS	168160
Centrarchidae	*Pomoxis nigromaculatus*	BLACK CRAPPIE	168167
Centrarchidae	*Ambloplites rupestris*	ROCK BASS	168097
Centrarchidae	*Pomoxis annularis*	WHITE CRAPPIE	168166
Embiotocidae	*Cymatogaster aggregata*	SHINER PERCH	169739
Moronidae	*Morone saxatilis*	STRIPED BASS	167680
Percidae	*Perca flavescens*	YELLOW PERCH	168469
Percidae	*Sander vitreus*	WALLEYE	168506
Percopsidae	*Percopsis transmontana*	SAND ROLLER	164410
Petromyzontidae	*Lampetra spp.*	LAMPREY[a]	159700
Petromyzontidae	*Lampetra richardsoni*	WESTERN BROOK LAMPREY	159707
Petromyzontidae	*Lampetra ayresii*	RIVER LAMPREY	622248
Petromyzontidae	*Lampetra tridentata*	PACIFIC LAMPREY	159713
Pleuronectidae	*Platichthys stellatus*	STARRY FLOUNDER	172893
Osmeridae	*Spirinchus thaleichthys*	LONGFIN SMELT	162049
Osmeridae	*Hypomesus pretiosus*	SURF SMELT	162030
Osmeridae	*Thaleichthys pacificus*	EULACHON	162051

Salmonidae	*Oncorhynchus mykiss*	RAINBOW TROUT OR STEELHEAD	161989
Salmonidae	*Salvelinus confluentus*	BULL TROUT	162004
Salmonidae	*Oncorhynchus kisutch*	COHO SALMON	161977
Salmonidae	*Oncorhynchus clarkii*	CUTTHROAT TROUT	161983
Salmonidae	*Prosopium williamsoni*	MOUNTAIN WHITEFISH	162009
Salmonidae	*Salvelinus namaycush*	LAKE TROUT	162002
Salmonidae	*Prosopium coulterii*	PYGMY WHITEFISH	162011
Salmonidae	*Thymallus arcticus*	ARCTIC GRAYLING	162016
Salmonidae	*Salvelinus malma*	DOLLY VARDEN	162000
Salmonidae	*Coregonus clupeaformis*	LAKE WHITEFISH	161941
Salmonidae	*Oncorhynchus nerka*	SOCKEYE SALMON	161979
Salmonidae	*Salmo trutta*	BROWN TROUT	161997
Salmonidae	*Oncorhynchus keta*	CHUM SALMON	161976
Salmonidae	*Oncorhynchus gorbuscha*	PINK SALMON	161975
Salmonidae	*Oncorhynchus tshawytscha*	CHINOOK SALMON	161980
Salmonidae	*Salvelinus fontinalis*	BROOK TROUT	162003
Salmonidae	*Oncorhynchus aguabonita*	GOLDEN TROUT	161987
Cottidae	*Cottus aleuticus*	COASTRANGE SCULPIN	167230
Cottidae	*Cottus gulosus*	RIFFLE SCULPIN	167234
Cottidae	*Cottus beldingii*	PAIUTE SCULPIN	167238
Cottidae	*Cottus cognatus*	SLIMY SCULPIN	167232
Cottidae	*Cottus asper*	PRICKLY SCULPIN	167233
Cottidae	*Cottus bairdii*	MOTTLED SCULPIN	167237
Cottidae	*Cottus confusus*	SHORTHEAD SCULPIN	167240
Cottidae	*Cottus perplexus*	RETICULATE SCULPIN	167248
Cottidae	*Leptocottus armatus*	PACIFIC STAGHORN SCULPIN	167302
Cottidae	*Cottus marginatus*	MARGINED SCULPIN	167247
Cottidae	*Cottus rhotheus*	TORRENT SCULPIN	167252
Ictaluridae	*Noturus gyrinus*	TADPOLE MADTOM	164003
Ictaluridae	*Ameiurus natalis*	YELLOW BULLHEAD	164041
Ictaluridae	*Ameiurus melas*	BLACK BULLHEAD	164039
Ictaluridae	*Pylodictis olivaris*	FLATHEAD CATFISH	164029
Ictaluridae	*Ictalurus punctatus*	CHANNEL CATFISH	163998
Ictaluridae	*Ameiurus nebulosus*	BROWN BULLHEAD	164043

[a]There is no field taxonomic key for lamprey larvae (ammocoetes) in Washington.

Table T-2. Scientific name, common name, and taxonomic serial number (ITIS, 2009) for amphibians that inhabit Washington.

FAMILY	SCIENTIFIC NAME	COMMON NAME	ITIS_SN
Frogs and Toads			
Ascaphidae	*Ascaphus truei*	TAILED FROG	173546
Ascaphidae	*Ascaphus montanus*	ROCKY MOUNTAIN TAILED FROG	661593
Bufonidae	*Bufo woodhousii*	WOODHOUSE'S TOAD	173476
Bufonidae	*Bufo boreas*	WESTERN TOAD	173482
Hylidae	*Pseudacris regilla*	PACIFIC TREEFROG	207313
Pelobatidae	*Spea intermontana*	GREAT BASIN SPADEFOOT	206991
Ranidae	*Rana clamitans*	GREEN FROG	173438
Ranidae	*Rana catesbeiana*	AMERICAN BULLFROG	173441
Ranidae	*Rana aurora*	RED-LEGGED FROG	173446
Ranidae	*Rana cascadae*	CASCADES FROG	173450
Ranidae	*Rana luteiventris*	COLUMBIA SPOTTED FROG	550546
Ranidae	*Rana pipiens*	NORTHERN LEOPARD FROG	173443
Ranidae	*Rana pretiosa*	OREGON SPOTTED FROG	173458
Salamanders and Newts			
Ambystomatidae	*Ambystoma macrodactylum*	LONG-TOED SALAMANDER	173601
Ambystomatidae	*Ambystoma gracile*	NORTHWESTERN SALAMANDER	173597
Ambystomatidae	*Ambystoma mavortium*	WESTERN TIGER SALAMANDER	668193
Dicamptodontidae	*Dicamptodon tenebrosus*	PACIFIC GIANT SALAMANDER	550242
Dicamptodontidae	*Dicamptodon copei*	COPE'S GIANT SALAMANDER	173742
Dicamptodontidae	*Dicamptodon spp.*	GIANT SALAMANDER	173740
Plethodontidae	*Plethodon larselli*	LARCH MOUNTAIN SALAMANDER	173662
Plethodontidae	*Plethodon dunni*	DUNN'S SALAMANDER	173654
Plethodontidae	*Ensatina eschscholtzii*	ENSATINA	173732
Plethodontidae	*Plethodon vandykei*	VAN DYKE'S SALAMANDER	173671
Plethodontidae	*Plethodon vehiculum*	WESTERN RED-BACKED SALAMANDER	173672
Rhyacotritonidae	*Rhyacotriton olympicus*	OLYMPIC TORRENT SALAMANDER	173745
Rhyacotritonidae	*Rhyacotriton cascadae*	CASCADE TORRENT SALAMANDER	550250
Rhyacotritonidae	*Rhyacotriton kezeri*	COLUMBIA TORRENT SALAMANDER	550251
Salamandridae	*Taricha granulosa*	ROUGH-SKINNED NEWT	173620

Animal Lengths

Record the minimum and maximum length (mm) of each *species-life stage* for the DCE. Measure the total length for every *species-life stage*, except for adult frogs. These are measured from snout to vent. Do not measure all individuals, only those that are smaller or larger than those already observed.

Voucher specimens

Voucher specimens will be obtained for all species captured, to verify field identifications. In the large majority of cases the voucher will consist of photographs from representative specimens using guidelines of Stauffer *et al* (2001) and AREMP (2007). Record an audio tag to each photograph with a description of each specimen, location, and date. Try to capture the relevant features that distinguish species. For example, for suckers, not only capture a lateral view, but also try to capture a ventral image of the head and jaw.

In a few cases, hard-to-photograph specimens (e.g. small individuals) of fishes may be preserved in a labeled polyethylene jar. Fill each jar with ethanol by diluting a 95% stock solution (2:1) in water including the fish (Bean, 1882). After a day or two, replace this with a stronger ethanol solution (3:1of ethanol to water). This should preserve the fish for a few months for more close examination in the laboratory. Complete 2 tags (Figure T-3) on Write-In-Rain paper. Insert one inside the jar; tape the other to the outside. Keep species separated.

<table>
<tr><td colspan="2">SITE_ID: WAM06600- ___ ___ ___ ___ ___ ___</td><td colspan="3">Crew No. (e.g, 1,2 etc) _____</td></tr>
<tr><td>Month</td><td>Day</td><td colspan="2">20__ __</td><td>ITIS_SN</td></tr>
<tr><td colspan="4">Stream Name</td><td>__ __ __ __ __ __</td></tr>
<tr><td colspan="2">Common Name</td><td colspan="2">Life Stage</td><td>Comments</td></tr>
<tr><td>Specimen 1 total length (mm):</td><td></td><td>J</td><td>A</td><td></td></tr>
<tr><td>Specimen 2 total length (mm):</td><td></td><td>J</td><td>A</td><td></td></tr>
<tr><td>Specimen 3 total length (mm):</td><td></td><td>J</td><td>A</td><td></td></tr>
<tr><td>Specimen 4 total length (mm):</td><td></td><td>J</td><td>A</td><td></td></tr>
<tr><td>Specimen 5 total length (mm):</td><td></td><td>J</td><td>A</td><td></td></tr>
</table>

Figure T-3. Label (on Write-in-Rain paper) for voucher jars or for DNA samples.

In even fewer cases, the crew will decide that DNA-based identification might be necessary. Whole specimens should be placed into a zip-sealed bag, labeled (Figure T-3), kept on ice, and delivered (frozen) to a local museum. Lamprey ammocoetes are examples of fish that should be represented in DNA analysis.

FPARS Type

For sites where field sampling is prohibited (no permits), analyze the FPARS Type and record the value on the Vertebrate Collection Form (Figure T-2). Perform this activity any time during the index period (July1 to October 15). This activity is performed by examining the FPARS interactive map (WDNR, 2009) to determine which code best applies to the stream site. Acceptable choices are “F” (Fish bearing) or “N” (Not fish bearing).

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Appendix U

Field Forms for Washington Status and Trends

There are 9 data forms that will be scanned using the Teleform system to enter data into the Status and Trends system. These are:

- *GPS Positions Form*
- *Site Verification Form*
- *Site Diagram*
- *Chemistry and Sampling Form*
- *Discharge Worksheet*
- *Major Transect Form*
- *Thalweg Data Form*
- *Slope and Bearing Form*
- *Vertebrate Collection Form*

Except for the 2-sided *Vertebrate Collection Form*, these occur back-to back (Table U-1).

Table U-1. The juxtaposition of field forms and number of copies needed per data collection event (DCE).

Front Side	Back side	Copies per DCE
Site Verification Form	Site Diagram	1
Chemistry and Sampling Form	Discharge Worksheet	1
Major Transect Form	Thalweg Data Form	11
Slope and Bearing Form	GPS Positions Form	1
Vertebrate Collection Form front	Vertebrate Collection Form back	1

See figures U-1 to U-10 for each of the forms that will be scanned into the Status and Trends Database using the Teleform system.

Reviewed by (Initials):________

Status and Trends Program - Site Verification Form 2009

	Site Number	YY	MMDD	HH : MM
DCE:	W A M 0 6 0 0 -	- D C E - 2 0	-	- :

DCE Start Date	/ / 2 0 0 9	DCE End Date	/ / 2 0 0 9

Water Name:

Waterbody Type: Saltwater/Brackish ☐ River/Stream ☐ Canal/Ditch ☐ Wetland ☐ Reservoir ☐ Lake ☐ Other ☐

Safe to Sample?:	Y N	If not sampled, why not?
Permission?:	Y N	
Sampled?:	Y N	
Wade or Raft?:	W R	

Crew	1 (Leader)	Crew Member 2	Crew Member 3	Crew Member 4
First Name / Last Name:				
Organization:				
Habitat:	☐	☐	☐	☐
Water:	☐	☐	☐	☐
Sediment:	☐	☐	☐	☐
Invertebrates:	☐	☐	☐	☐
Fishing:	☐	☐	☐	☐

Other People?

Montgomery & Buffington Reach Type	Bankfull Width Estimate near Index Station (avg. of 5) (m)	Site Length 20 x BFW but between 150-2000 (m)
	Downstream Thalweg Distance (X to A) (m.x)	Upstream Thalweg Distance (X to A) (m.x)

Colluvial ☐
Alluvial:Braided ☐
Alluvial:Regime ☐
Alluvial:Pool-Riffle ☐
Alluvial:Plane Bed ☐
Alluvial:Step Pool ☐
Alluvial:Cascade ☐
Bedrock ☐

General Notes

Draft

Figure U-1. The Site Verification Form.

Is the site unsafe to access, or with barriers that prevent access (round trip) and sampling by wading within one day? Y N

Is the site unsafe to access, or with barriers that prevent access (round trip) and sampling by raft within one day? Y N

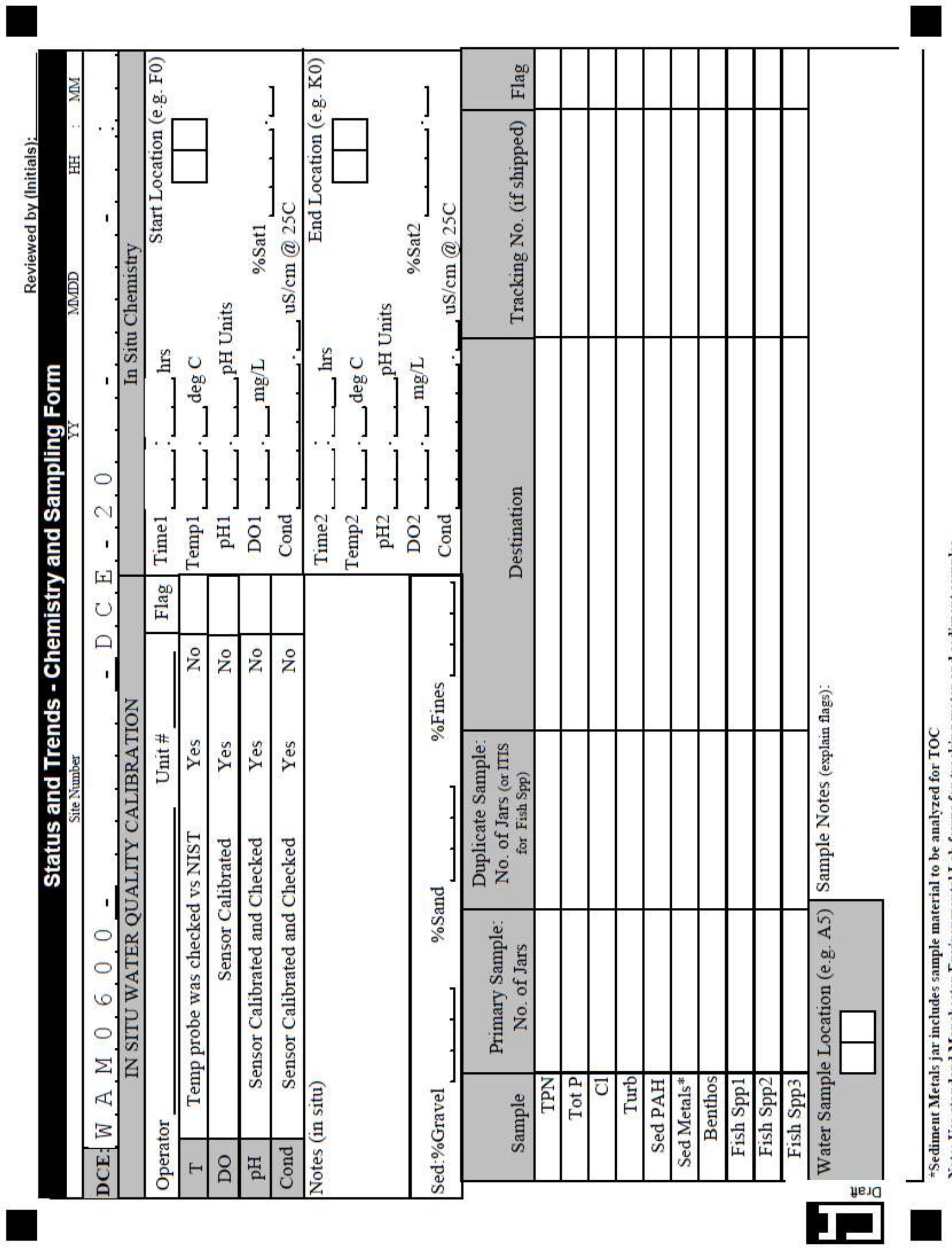
Why is it inaccessible?

SITE DIAGRAM

Provide North Arrow

Draft

Figure U-2. The Site Diagram Form.


Status and Trends - Chemistry and Sampling Form

Reviewed by (Initials):

DCE: W A M 0 6 0 0 0 - D C E - 2 0 _ _ - _ _ _ _ - _ _ : _ _

Site Number YY MMDD HH : MM

IN SITU WATER QUALITY CALIBRATION				
Operator		Unit #		Flag
T	Temp probe was checked vs NIST	Yes	No	
DO	Sensor Calibrated	Yes	No	
pH	Sensor Calibrated and Checked	Yes	No	
Cond	Sensor Calibrated and Checked	Yes	No	

Notes (in situ)

Sed:%Gravel ____ %Sand ____ %Fines ____

In Situ Chemistry

Time1 __ : __ hrs Start Location (e.g. F0)

Temp1 ____ deg C

pH1 ____ pH Units

DO1 ____ mg/L %Sat1 ____

Cond ____ uS/cm @ 25C

Time2 __ : __ hrs End Location (e.g. K0)

Temp2 ____ deg C

pH2 ____ pH Units

DO2 ____ mg/L %Sat2 ____

Cond ____ uS/cm @ 25C

Sample	Primary Sample: No. of Jars	Duplicate Sample: No. of Jars (or ITIS for Fish Spp)	Destination	Tracking No. (if shipped)	Flag
TPN					
Tot P					
Cl					
Turb					
Sed PAH					
Sed Metals*					
Benthos					
Fish Spp1					
Fish Spp2					
Fish Spp3					

Water Sample Location (e.g. A5)

Sample Notes (explain flags):

*Sediment Metals jar includes sample material to be analyzed for TOC

Note: Use standard Manchester Environmental Lab forms for tracking water and sediment samples.

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Figure U-3. The Chemistry and Sampling Form.

Flow Location - Thalweg Station (e.g. A5) : ___ Flow Meter (Model / Unit #) ________ / ____

Discharge Worksheet

Flow Meter Zeroed Out?	Y N	Wetted Width:	

Cell	Tape Distance Left to Right (cm)	Wetted Depth (ft.x)	Velocity (ft.xx/s)	Notes
01				Left edge of water
02				
03				
04				
05				
06				
07				
08				
09				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				Right wetted margin

Describe Alternate Method:	Flow Method: (circle one)	Flow Meter	Time of Travel
		Bucket Flow	Gage

Discharge: __ , ___ . __ cfs

Notes (discharge)

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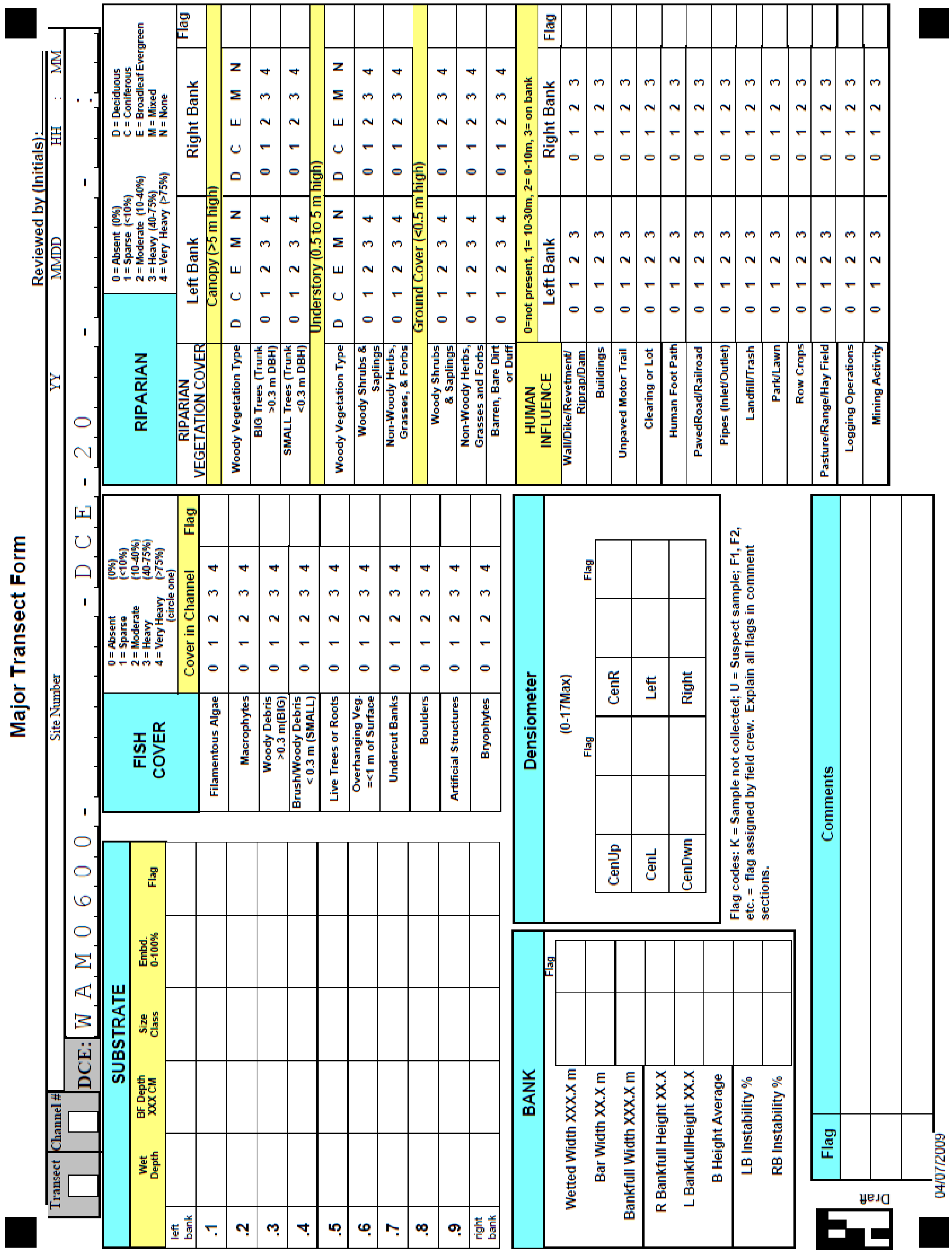
Figure U-4. The Discharge Worksheet.



Major Transect Form

Reviewed by (Initials):

Transect	Channel #	DCE:	Site Number	YY	MMDD	HH : MM
			W A M 0 6 0 0 -	- D C E - 2 0	-	- :

SUBSTRATE

	Wet Depth	BF Depth XXX CM	Size Class	Embd. 0-100%	Flag
left bank					
.1					
.2					
.3					
.4					
.5					
.6					
.7					
.8					
.9					
right bank					

FISH COVER

0 = Absent (0%)
1 = Sparse (<10%)
2 = Moderate (10-40%)
3 = Heavy (40-75%)
4 = Very Heavy (>75%)
(circle one)

	Cover in Channel	Flag
Filamentous Algae	0 1 2 3 4	
Macrophytes	0 1 2 3 4	
Woody Debris >0.3 m(BIG)	0 1 2 3 4	
Brush/Woody Debris < 0.3 m (SMALL)	0 1 2 3 4	
Live Trees or Roots	0 1 2 3 4	
Overhanging Veg. =<1 m of Surface	0 1 2 3 4	
Undercut Banks	0 1 2 3 4	
Boulders	0 1 2 3 4	
Artificial Structures	0 1 2 3 4	
Bryophytes	0 1 2 3 4	

RIPARIAN

0 = Absent (0%)
1 = Sparse (<10%)
2 = Moderate (10-40%)
3 = Heavy (40-75%)
4 = Very Heavy (>75%)

D = Deciduous
C = Coniferous
E = Broadleaf Evergreen
M = Mixed
N = None

RIPARIAN VEGETATION COVER	Left Bank	Right Bank	Flag
Canopy (>5 m high)			
Woody Vegetation Type	D C E M N	D C E M N	
BIG Trees (Trunk >0.3 m DBH)	0 1 2 3 4	0 1 2 3 4	
SMALL Trees (Trunk <0.3 m DBH)	0 1 2 3 4	0 1 2 3 4	
Understory (0.5 to 5 m high)			
Woody Vegetation Type	D C E M N	D C E M N	
Woody Shrubs & Saplings	0 1 2 3 4	0 1 2 3 4	
Non-Woody Herbs, Grasses, & Forbs	0 1 2 3 4	0 1 2 3 4	
Ground Cover (<0.5 m high)			
Woody Shrubs & Saplings	0 1 2 3 4	0 1 2 3 4	
Non-Woody Herbs, Grasses and Forbs	0 1 2 3 4	0 1 2 3 4	
Barren, Bare Dirt or Duff	0 1 2 3 4	0 1 2 3 4	

HUMAN INFLUENCE 0=not present, 1= 10-30m, 2= 0-10m, 3= on bank

	Left Bank	Right Bank	Flag
Wall/Dike/Revetment/ Riprap/Dam	0 1 2 3	0 1 2 3	
Buildings	0 1 2 3	0 1 2 3	
Unpaved Motor Trail	0 1 2 3	0 1 2 3	
Clearing or Lot	0 1 2 3	0 1 2 3	
Human Foot Path	0 1 2 3	0 1 2 3	
PavedRoad/Railroad	0 1 2 3	0 1 2 3	
Pipes (Inlet/Outlet)	0 1 2 3	0 1 2 3	
Landfill/Trash	0 1 2 3	0 1 2 3	
Park/Lawn	0 1 2 3	0 1 2 3	
Row Crops	0 1 2 3	0 1 2 3	
Pasture/Range/Hay Field	0 1 2 3	0 1 2 3	
Logging Operations	0 1 2 3	0 1 2 3	
Mining Activity	0 1 2 3	0 1 2 3	

BANK

		Flag
Wetted Width XXX.X m		
Bar Width XX.X m		
Bankfull Width XXX.X m		
R Bankfull Height XX.X		
L BankfullHeight XX.X		
B Height Average		
LB Instability %		
RB Instability %		

Densiometer

(0-17Max)

		Flag			Flag
CenUp			CenR		
CenL			Left		
CenDwn			Right		

Flag codes: K = Sample not collected; U = Suspect sample; F1, F2, etc. = flag assigned by field crew. Explain all flags in comment sections.

Flag	Comments

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04/07/2009

Figure U-5. The Major Transect Form.

Thalweg Data Form

Reviewed by (Initials): ______

	Site Number	YY	MMDD	HH : MM
DCE:	W A M 0 6 0 0 - ____	- D C E - 2 0 __	- ____	- __ : __

Transect ☐	Thalweg Depth (cm)	Bar? (circle)	Edge Pool? (circle)	Habitat Unit Number	Side Channel Numbers					Wet Width (m.x)	BF Width (m.x)	Bar Width (m.x)	Thalweg Notes:
.0		Y N	Y N										
.1		Y N	Y N										
.2		Y N	Y N										
.3		Y N	Y N										
.4		Y N	Y N										
.5		Y N	Y N										
.6		Y N	Y N										
.7		Y N	Y N										
.8		Y N	Y N										
.9		Y N	Y N										

Substrates at 5	LB	01	02	03	04	05	06	07	08	09	RB	Substrate Notes:

Habitat Unit Number	Habitat Unit Type FT, FN, PS, PD, PP, DC	Pool Forming Code (N, W, R, B, F) Code 1	Code 2	HU Width (m.x)	Max Pool Depth (cm)	Crest Pool Depth (cm)	Channel Unit Notes:

Side Channel Number	Width (m.x)	Side Channel Notes:

LWD Count — Example: ~~||||~~ | 6 — Check box if all are zero ☐

LWD Count	2-5 m	5-15 m	>15 m	Flag
10-30 cm				
30-60 cm				
60-80 cm				
>80 cm				

LWD Notes:

Draft

Figure U-6. The Thalweg Data Form

Reviewed by (Initials):__________

Status & Trends - Slope and Bearing Form

Site Number YY MMDD HH : MM

DCE: W A M 0 6 0 0 - _ _ _ _ _ _ _ - D C E - 2 0 _ _ - _ _ _ _ - _ _ : _ _

Top Transect* LEVEL, COMPASS	Bottom Transect* ROD	Segment Length (m.x)	Eye Height on Level (cm)	Level Height on Rod (cm)	Bearing (deg)	Flag	Comment

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*Normally sight between major and minor transects: K0 to J5, J5 to J0, J0 to I5, etc, unless there is a need for intermediate measurements. For intermediate measurements, always sight to/from a transect station 0-9 (for example K0 to J7 and J7 to J5). Bearings are magnetic north facing downstream (not adjusted).

Figure U-7. The Slope and Bearing Form.

Reviewed by (Initials):________

Status and Trends Program - GPS Positions Form

Site Number		YY	MMDD	HH : MM
DCE: W A M 0 6 0 0 -	- D C E - 2 0	-	-	:

Station	Bank (circle one)	Master Lat dec deg e.g. 47.123456	Master Lon dec deg e.g. 120.123456	GPSlatDD e.g. 47.123456	GPSLonDD e.g. 120.123456	Accuracy	Accuracy Units (ft, EPE, etc.)	Flag
INDEX STATION	L R							
A0	L R							
B0	L R							
C0	L R							
D0	L R							
E0	L R							
F0	L R							
G0	L R							
H0	L R							
I0	L R							
J0	L R							
K0	L R							
PUTIN	L R							
TAKEOUT	L R							

ALL COORDINATES TO BE RECORDED IN NAD83

Position comments including accuracy

Directions to access point

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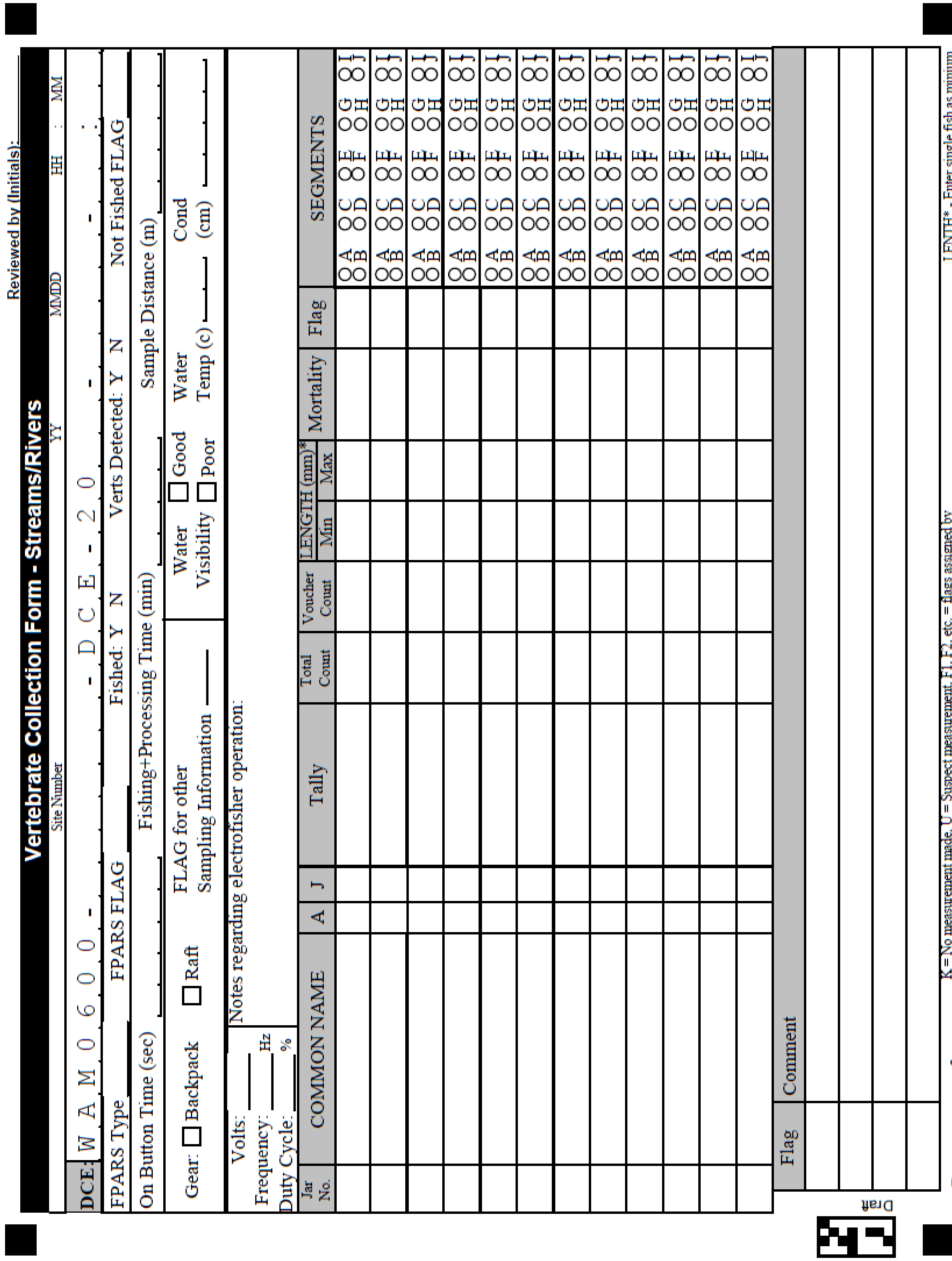
Figure U-8. The GPS Positions Form.


Reviewed by (Initials): ____

Vertebrate Collection Form - Streams/Rivers

DCE: W A M 0 6 0 0 - ____ - D C E - 2 0 __ - ____ - ____ : ____

Site Number   MMDD   YY   HH : MM

FPARS Type ____ FPARS FLAG ____ Fished: Y N   Verts Detected: Y N   Not Fished FLAG ____

On Button Time (sec) ____ Fishing+Processing Time (min) ____ Sample Distance (m) ____

Gear: ☐ Backpack ☐ Raft   FLAG for other Sampling Information ____   Water Visibility ☐ Good ☐ Poor   Water Temp (c) ____   Cond (cm) ____

Volts: ____
Frequency: ____ Hz
Duty Cycle: ____ %

Notes regarding electrofisher operation:

Jar No.	COMMON NAME	A	J	Tally	Total Count	Voucher Count	LENGTH (mm)* Min	Max	Mortality	Flag	SEGMENTS
											○A ○B ○C ○D ○E ○F ○G ○H ○I ○J
											○A ○B ○C ○D ○E ○F ○G ○H ○I ○J
											○A ○B ○C ○D ○E ○F ○G ○H ○I ○J
											○A ○B ○C ○D ○E ○F ○G ○H ○I ○J
											○A ○B ○C ○D ○E ○F ○G ○H ○I ○J
											○A ○B ○C ○D ○E ○F ○G ○H ○I ○J
											○A ○B ○C ○D ○E ○F ○G ○H ○I ○J
											○A ○B ○C ○D ○E ○F ○G ○H ○I ○J
											○A ○B ○C ○D ○E ○F ○G ○H ○I ○J
											○A ○B ○C ○D ○E ○F ○G ○H ○I ○J
											○A ○B ○C ○D ○E ○F ○G ○H ○I ○J
											○A ○B ○C ○D ○E ○F ○G ○H ○I ○J

Flag	Comment

Page ____ of ____   K = No measurement made, U = Suspect measurement, F1, F2, etc. = flags assigned by each field crew   LENTH* - Enter single fish as minium

Draft

Figure U-9. The Vertebrate Collection Form (front).

Tag No.	COMMON NAME	A	J	Tally	Total Count	Voucher Count	LENGTH (mm)*		Mortality	Flag	SEGMENTS
							Min	Max			
											○A ○B ○C ○D ○E ○F ○G ○H ○I ○J
											○A ○B ○C ○D ○E ○F ○G ○H ○I ○J
											○A ○B ○C ○D ○E ○F ○G ○H ○I ○J
											○A ○B ○C ○D ○E ○F ○G ○H ○I ○J
											○A ○B ○C ○D ○E ○F ○G ○H ○I ○J
											○A ○B ○C ○D ○E ○F ○G ○H ○I ○J
											○A ○B ○C ○D ○E ○F ○G ○H ○I ○J
											○A ○B ○C ○D ○E ○F ○G ○H ○I ○J
											○A ○B ○C ○D ○E ○F ○G ○H ○I ○J
											○A ○B ○C ○D ○E ○F ○G ○H ○I ○J
											○A ○B ○C ○D ○E ○F ○G ○H ○I ○J
											○A ○B ○C ○D ○E ○F ○G ○H ○I ○J
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											○A ○B ○C ○D ○E ○F ○G ○H ○I ○J
											○A ○B ○C ○D ○E ○F ○G ○H ○I ○J
											○A ○B ○C ○D ○E ○F ○G ○H ○I ○J

Flag	Comment

Draft

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K = No measurement made, U = Suspect measurement, F1, F2, etc. = flags assigned by each field crew

LENTH* - Enter single fish as minium.

Figure U-10. The Vertebrate Collection Form (back).

Appendix V

Field Equipment Checklist

Field equipment and supplies are listed in Table V-1.

Table V-1. Field equipment checklist.

Category	Item
General	No. 2 Pencils
General	Pencil sharpener
General	Waders/Boots
General	Backpacks
General	This manual
General	Clip Boards (3): Habitat, Chemistry, Vertebrates
General	Camera
General	Calculator
General	Field notebook
General	Stopwatch
General	Calipers
Forms and labels	Site Verification Form x Site Diagram (1)
Forms and labels	Chemistry and Sampling Form x Discharge Worksheet (1)
Forms and labels	Major Transect Form x Thalweg Data Form (11)
Forms and labels	The Vertebrate Collection Form front and back (1)
Forms and labels	Slope and Bearing Form x GPS Positions (1)
Forms and labels	Calibration Form (1)
Forms and labels	Laboratory Analyses Required Form
Forms and labels	Water Sample Tags (with laboratory-assigned sample numbers)
Forms and labels	Sediment Sample Tags (with laboratory-assigned sample numbers)
Forms and labels	Benthos Label (waterproof) for jar exterior
Forms and labels	Benthos Label (waterproof) for jar interior

Table V-1. (continued).

Category	Item
Calibration	Hydrolab, components, maintenance kit
Calibration	Hydrolab Manuals
Calibration	QCCS
Calibration	pH 7 buffer (7.00) - e.g. VWR - 23197-996
Calibration	pH 4 buffer (4.01) - e.g. VWR - 23197-998
Calibration	pH 10 buffer (10.01) - e.g. VWR - 23197-994
Calibration	pH 7 standard (6.97) - e.g. Thermo 700702
Calibration	pH 4 standard (4.10) - e.g. Thermo 700402
Calibration	pH 9 standard (9.15) - e.g. Thermo 700902
Calibration	Conductivity Standard (100 ?S) - e.g. VWR 23226-589
Calibration	Conductivity Standard (1,000 ?S) - e.g. VWR 23226-603
Calibration	Conductivity Standard (alternate as available)
Calibration	De-ionized water (DI)
Calibration	Tap Water
Calibration	Lab tissues (e.g. KimWipes®)
Calibration	Barometer
Calibration	Winkler sampling supplies
In situ	Hydrolab, components, maintenance kit
In situ	Hydrolab Manuals
Water Sampling	Gloves - Non-powdered nitrile
Water Sampling	Garbage bag
Water Sampling	Cooler, Ice
Water Sampling	Jar#26 for TP
Water Sampling	Jar#19 for TPN
Water Sampling	Jar#22 for Cl
Water Sampling	Jar#22 for TURB
Water Sampling	Jar#23 for TSS
Discharge	Flow Meter
Discharge	Flow Meter Manual
Discharge	Batteries
Discharge	Wading rod (top setting)
Discharge	Orange or other neutrally buoyant object.
Discharge	5-gallon bucket

Table V-1. (continued).

Category	Item
Sediment sampling	Stainless steel bowl with sealed stainless steel cover (about 6)
Sediment sampling	Stainless steel spoon (about 6)
Sediment sampling	Turkey baster (3) or 60-cc syringe (3)
Sediment sampling	Gloves - Non-powdered nitrile
Sediment sampling	Cooler, Ice
Sediment sampling	Garbage Bag
Sediment sampling	Jars (provided by the laboratory)
Sediment sampling	Aluminum foil
Benthos sampling	Wide-mouth polyethylene jar (128 oz or 3.8 L)
Benthos sampling	D-Frame kick net with handle and frame
Benthos sampling	95% Ethanol (add 3 parts by volume for each part sample)
Benthos sampling	Clear tape
Benthos sampling	Electrical tape
Habitat	GPS
Habitat	Maps
Habitat	measuring rod
Habitat	50-m tape
Habitat	laser rangefinder
Habitat	hand level with monopod
Habitat	clinometer
Habitat	PVC ring with 10-cm ID
Habitat	Modified convex densiometer
Habitat	Flagging
Habitat	Permanent marker
Habitat	Calipers
Habitat	Field notebook
Habitat	compass

Table V-1. (continued).

Category	Item
Vertebrates	Permits
Vertebrates	Backpack electrofisher unit (e.g. Smith-Root LR-20)
Vertebrates	Anode with ring
Vertebrates	Cathode (rat-tail)
Vertebrates	Battery (fully charged)
Vertebrates	Electrically insulated gloves
Vertebrates	Polarized sun glasses
Vertebrates	Caps with visor
Vertebrates	Measuring Board
Vertebrates	Taxonomic Keys
Vertebrates	Buckets or live wells
Vertebrates	Dipnet (1/8” mesh)
Vertebrates	Aquarium net
Vertebrates	Loop or magnifying glass
Vertebrates	Small Cooler with ice, zip-sealing bag, and tag (voucher sample).
Vertebrates	A couple of 500-1000 ml jars with ethanol (lab. checks)
Vertebrates	Abrasive cloth for electrode maintenance